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Building Resilient Farming Communities in the UK: Encouraging Agroecological Practices on UK Farms in Relation to Climate Change

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Building Resilient Farming Communities in the UK: Encouraging Agroecological Practices on UK Farms in Relation to Climate Change

By

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ETHICS REVIEW FEEDBACK FORM

(Review feedback should be completed within 10 working days)

Name of applicant: Katharine Hartless Rose..................

Faculty/School/Department: [University Research Centre] Centre for Agroecology, Water and Resilience

Research project title: Phase 2 data collection Regenerative Agriculture UK

Comments by the reviewer

1. Evaluation of the ethics of the proposal:

This is a very clear and comprehensive ethical evaluation, which outlines all the associated risks and ethical issues likely to be encountered during field work. It also presents clear strategies for minimising risks and for ensuring data protection protocols are followed.

2. Evaluation of the participant information sheet and consent form:

The participant information sheet provides a clear explanation of the purpose of the research and outlines in detail how the information collected will be used. The form also seeks consent for a variety of different aspects to the research and makes a useful distinction between those participants who are willing to attribute their names to quotes and those who would wish to remain anonymous.

3. Recommendation:

(Please indicate as appropriate and advise on any conditions. If there any conditions, the applicant will be required to resubmit his/her application and this will be sent to the same reviewer).

X	Approved - no conditions attached
	Approved with minor conditions (no need to re-submit)
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Date: 22/05/2015...

Abstract

Faced with a future including environmental impacts on agriculture and food production from climate change, alongside a growing population: this thesis considers agroecology and sustainable agriculture farming practices to enable farmers in the UK to have climate-resilient livelihoods. The research explores existing agroecological interventions in the UK, along with drivers and barriers to changing behaviour amongst those farmers towards using agroecological techniques. Through an investigation of sustainable livelihoods, an analytical framework was developed to assist with the data collection and analysis. Using a mixed method study of data collection, the first phase comprised a quantitative and qualitative survey, and the second phase an in-depth qualitative individual and group interviews. The results were analysed using a conceptual model of resilient rural agricultural livelihoods in the UK.

By comparing back to the theory and concepts, the results were discussed and evaluated. These included the importance of sustainable livelihoods in assessing agroecology and sustainable farming in the UK. Evaluation of the results highlighted the following issues: hazards to farmers from climate change through to finances; how farmer assets (social, human, natural, financial and physical) can help build resilience to those hazards; and how barriers to change - including sociological and psychological barriers - can reduce a farmer's assets and increase their vulnerability to climate change and other hazards.

Key findings included one which has already been acknowledged to be important for climate-resilient agriculture, which was to improve soil health, both for improved nutrients, but also for carbon sequestration and water retention. Another key finding was the emergence of the "digital electronic hedge" for farmer learning, mentoring and communication. Through video, social media, web forums and email, farmers are collapsing geographical barriers to look over their 'neighbour's hedge' at opposite ends of the country. Furthermore, the same mediums can bridge the gap between farmers and researchers which can be important for extending new techniques and theories.

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List of abbreviations and acronyms

AES: Agri Environmental Schemes

AFBI: Agri-Food and Biosciences Institute

AHDB: Agriculture and Horticulture Development Board

APPG: All-Party Parliamentary Group

ASRLF: Agroecology and Sustainable Rural Livelihoods Framework

BOS: Bristol Online Survey

CALM: Carbon Accounting for Land Managers

CAP: Common Agriculture Policy

CAWR: Centre for Agroecology, Water and Resilience, Coventry University

CCC: The Committee on Climate Change

CH_4: Methane

CLA: Country Land and Business Association

CO_2: Carbon Dioxide

CPRE: Campaign to Protect Rural England

CSA: Community Supported Agriculture

DAERA: Department of Agriculture, Environment and Rural Affairs (Northern Ireland) - formally DARD

DairyCo: now known as AHDB Dairy

DARD: Department of Agriculture and Rural Development (Northern Ireland) – now DAERA

DECC: UK Department of energy and climate change (now closed)

DEFRA: UK Department of Environment, Food and Rural Affairs

DfID: Department for Internationals Development

DOFF: Duchy Originals Future Farming

E-hedge: Digital Electronic hedge

EU: European Union

FAO: Food and Agriculture Organization of the United Nations

FBS: Farm Business Survey

FCC: Farm Carbon Calculator

FCCT: Farm Carbon Cutting Toolkit

FCN: Farming Community Network

FIT: Feed-in tariff

FYM: Farmyard Manure

GHGAP: Greenhouse Gas Action Plan

GHGs / GHG: Greenhouse gases / greenhouse gas

HULF: Household Urban Livelihoods Framework

HRC: Human Rights Council

IAASTD: The International Assessment of Agricultural Knowledge, Science and Technology for Development

IBERS: The Institute of Biological, Environmental and Rural Sciences

IDS: Institute of Development Studies, University of Sussex

IFAD: International Fund for Agricultural Development

IFOAM: International Federation of Organic Agriculture Movements

IFSA: International Farming Systems Association

IPCC: The Intergovernmental Panel on Climate Change

IT: Information Technology

ITPS: Intergovernmental Technical Panel on Soils

JMMR: Journal of Mixed Methods Research

kWh: Kilowatt Hour

LCF: Low Carbon Farming

LEAF: Linking Environment And Farming

LUCCG: Welsh Government Land Use Climate Change Group

LUPG: Land Use Policy Group

MetOffice: UK's National Meteorological Service

N_2O: Nitrous Oxide

NASA: National Aeronautics and Space Administration

NFU: National Farmers Union

NGOs: Non-governmental organisations

NHS: National Health Service

NOAA: National Oceanic and Atmospheric Administration

NVIVO: Name of the qualitative data analysis software package used during this research

OHCHR: Office of the United Nations High Commissioner for Human Rights

p: Pence

PFLA: Pasture Fed Livestock Association

PRA: Participatory Rural Appraisal

PV: Photovoltaic cells

RegenAG UK: Regenerative Agriculture UK

RSPB: Royal Society for the Protection of Birds

SLA: Sustainable Livelihood Approach

SLF: Sustainable Livelihood Framework

SPSS: Name for the statistical analysis software package used during this research

SRUC: Scotland's Rural College

SRL: Sustainable Rural Livelihoods

TB: Tuberculosis

TFF: The Farming Forum

TPB: Theory of Planned Behaviour

TRA: Theory of Reasoned Action

UK: United Kingdom of Great Britain and Northern Ireland

UN: United Nations

UN DESA: United Nations Department of Economic and Social Affairs

UNCCD: The United Nations Convention to Combat Desertification

UNFCCC: United Nations Framework Convention on Climate Change

UNISDR: United Nations Office for Disaster Risk Reduction

WFP: World Food Programme

WMO: World Meteorological Organization

List of definitions used in this thesis

Adaptation to climate change - The IPCC define adaptation to climate change as practices, techniques and initiatives that will reduce biological and human system vulnerabilities to climate change (Baede et al. 2007).

Agroecology –is defined as agriculture which considers farming's relationship with society, the economy and environment (Francis et al. 2003), whilst studying and applying ecological and socio-economic perspectives and principles to the design and organization of sustainable agroecosystems (Wibbelmann et al. 2013, Gliessman 1997). The practice of agroecology attempts to avoid any negative impact on the environment and improve a farm's biodiversity and natural resources such as water and soil. In addition to farming techniques and practices, agroecology considers the whole of the food chain from farm to fork, policies to planting (Agroecology Research Group 2014a) and encourages social movements to address political issues related to farming including food security (Fitzpatrick 2015).

Climate change mitigation – The IPCC define mitigation against climate change as policies and practices which reduce GHG emissions and improve carbon sinks, such as those locked in peat bogs, or in soil (Baede et al. 2007).

Climate-resilient farming – This is defined as farming which can be resilient to, (that is withstand, adapt to, recover from and mitigate against) any impacts of climate change.

Climate and weather – Weather is what experience every day, whilst climate is longer term. The Met Office describe weather as the temperature, precipitation (from snow to rain) and wind that occurs on a given day whilst climate is the 'identifiable patterns in different regions and over time' (Met Office Hadley Centre 2016a). NASA define them as 'climate is what you expect, like a very hot summer, and weather is what you get, like a hot day with pop-up thunderstorms' (NASA 2005).

Community – for the sake of this thesis, using the Oxford English Dictionary, community is defined as: 'A group of people living in the same place or having a particular characteristic in common…. A particular area or place considered together with its inhabitants' (Oxford English Dictionary 2017).

Livelihoods / sustainable livelihoods – Sustainable livelihoods explore how assets (social, human, natural, financial and physical[1]) can reduce a person's vulnerability to hazards, and enable them to access resources, thus sustaining their livelihood despite any challenges they may face.

Minimum Tillage – is defined as avoiding disturbing and inverting the soil and destroying the structure of the soil organic matter, thus tilling shallower than from conventional ploughing or turning the land (Cooper et al. 2016). There are various different types of minimum tillage including direct drilling, conservation tilling, and shallow and deep tillage without inversion (Wadsworth et al. 2003).

No-Tillage – (also known as zero tillage) - is defined as that which avoids tilling the soil altogether, although again there are different interpretations from creating small slots to plant seeds, to not using any mechanical tillage machines (Friedrich and Kassam 2012).

Resilience – For the purpose of this thesis, *resilience is understood as the ability (of a person, farm, community) to withstand, cope, adapt to, recover from, transform and mitigate against future shocks, stresses, hazards that may occur*. A discussion of the different definitions which form this can be found in Section 2.3.4.

[1] One example of explaining all these assets, uses the problem of poor soil fertility. Through a farmer gaining knowledge (human and social assets) to improve their soil (natural asset), their crop yield may improve (physical asset), potentially increasing the costs they would receive when selling that crop (financial asset).

Sustainability – The Foresight Committee's definition of sustainability is used in this thesis and states that 'the principle of sustainability implies the use of resources at rates that do not exceed the capacity of the earth to replace them' (Foresight 2011: 31).

Transitioning to AaSF – this is defined as a farmer who has begun to use climate-resilient or AaSF techniques as listed in 2.2.4 and 2.3.4, not just to be more economical, but also for the intention to adapt and mitigate climate change, or begin to farm more sustainability or agroecologically.

Chapter 1 – Introduction

1.1 Introduction, justification, and outline for the research

This research is focused on building climate-resilient farming communities and sustainable farming livelihoods in the UK, through the exploration of agroecological practices on UK farms[2]. The research explores agroecological interventions, and the drivers and barriers to behaviour change in farmers towards using agroecological practices that would help build climate-resilient farming communities, along with the implications of agroecological changes to the wider UK food system[3].

Looking first at the global context of climate change, an increasing population, and food security, as a justification for why the UK needs to change its farming practices, the chapter then focuses more specifically at the UK context. Considering the aim and research questions, the chapter then ends with a summary and outline of the entire thesis.

1.1.1 Justification

The current world population is now estimated to reach 9.7 billion by 2050 (UN DESA 2015). Yet food security needs to keep pace alongside this growth: currently 795 million people go hungry every day (FAO et al. 2015) and this figure merely considers those who suffer calorie deficiencies annually, not those who have seasons of low calorific input and seasons with greater amounts (Lappé et al. 2013), so in reality that figure is likely higher. In fact, the authors of *World Hunger: 10 Myths* estimate that if

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[2] In this thesis, there is a range across the scales, from referring to an individual or person (1), household (2-10), community (3-greater than 200), UK food system (millions). As community is defined as a group of people (see the definitions list), it can overlap with the household scale. In some parts of the thesis both terms are used, whilst in others, one or the other is used.

[3] It must be acknowledged that the positionality and worldview of the researcher, is that human made climate change is a reality and will influence food security as the population grows; hence farmers need to adapt in order to sustain their livelihoods and ensure food production. Agroecology and sustainable farming use techniques which can help farmers adapt. This creates a bias. However, discussions and considerations of opposing viewpoints have been included in an attempt to portray both sides of an argument.

stunted growth (which includes poor immune systems and reduced cognitive development) and nutrient deficiencies are factored into the calculations of those going hungry, then nearly a quarter of the global population suffers from nutritional deprivation (Lappé and Collins 2015). The authors describe 'nutritional deprivation' as 'being so deprived of healthy food –and the safe water needed to absorb its nutrients- that one's health suffers' (Lappé and Collins 2015: 16).

This is despite enough food currently being grown globally for every person on the planet to receive 2903 kcal a day (FAO 2015a), which is in excess of that calories that the human body needs per day (Lappé 2013) stated as 2500kcal for men and 2000kcal for women (Scientific Advisory Committee on Nutrition 2012). Hence, if we were able to distribute this equally, reduce food waste and reduce human edible food grown for biofuels or cattle, there would be enough to feed the global population (Holt-Giménez et al. 2012, Lappé 2013). In addition, with western diets influencing food consumption patterns, in some regions, not only is undernutrition a problem, but overnutrition is also causing problems, with obesity rising around the globe, increasing diet related diseases (FAO 2015b). This is also a nutritional deprivation issue because, particularly amongst women (Franklin et al. 2012), food insecurity is linked with obesity (Papan and Clow 2015), due to the fact that for people in certain countries, buying unhealthy, less nutritious food is cheaper than fresh unprepared food (Bhattacharya et al. 2004).

Another issue is that The Food and Agriculture Organization of the United Nations (FAO) estimate that one-third of food produced is wasted globally each year (FAO 2016), 1.3 billion tons, of which 91% is wasted by consumers in Europe and North America (Gustavsson et al. 2011). This not only leads to a loss in food, but also has implications for climate change in that the Greenhouse gas (GHG) emissions of the wasted food were produced needlessly (Gustavsson et al. 2011). Another issue is that, despite the World Bank estimation of 445 million hectares of nonforested, rain fed, uncultivated land potentially being available to grow more food[4] (Deininger et al. 2011), the FAO report that currently 33% of land globally is 'moderately to highly degraded' from chemical fertilisers and pesticides, erosion, acidification and compaction (FAO and ITPS 2015: XIX). This includes land used for grazing and arable. Fresh water is also a problem for many countries, both due to reduced supplies, but also due to contamination (Beddington et al. 2011).

Over the next few decades given an increasing population, there may be the pressure of an increased requirement for food on the entire food system. Godfray et al. suggest using a 'broad range of options', (2010: 817) including genetic modification and sustainable intensification, undertaken concurrently to meet demand. Godfray and Garnett later suggest sustainable intensification should include a variety of techniques of which one might be genetic modification (2014). Other options as discussed in an editorial of *Journal of Sustainable Agriculture*[5], suggest it would make more sense to resolve and reduce food wastage, improve food distribution globally, improve dietary nutrition, improve soil fertility, and reduce water and soil contamination across the globe, than continue to cultivate new land and increase yields through chemical inputs (Holt-Giménez et al. 2012).

Assuming a future in the UK that experiences both climate change and a reduction in fossil fuel supplies, both food security and farmers' livelihoods in the United Kingdom (UK) will be affected. How can the agriculture community produce sufficient, healthy food that will both feed the population and sustain the livelihoods of the farming community whilst adapting their farming methods to reduce GHG emissions?

[4] The report is unclear if this figure of 445 million hectares of extra land includes land previously degraded (Gliessman 2013). However, as the report does state that the land is currently uncultivated, it could be assumed that some land may have been fallow and started to recover from previous degradation.
[5] Which is now known as the *Journal of Agroecology and Sustainable Food Systems* (Deryng et al. 2016).

1.1.2 Climate change, and agriculture in the UK

Agriculture, forestry and other land use practices globally contribute 24% of the emissions of greenhouse gases (GHGs) that impact on climate (Smith et al. 2014). This is mainly through the use of fertilisers, fossil fuels for power on farms, numbers and management of ruminant livestock and flooded rice fields, and the conversion of habitats such as forest or peat land to fields and pastures that typically releases large amounts of carbon into the atmosphere (Gliessman 2015). Post farm gate emissions[6] across the food system from processing and transport of food also release GHG emissions. Looking more specifically at the UK, estimates for GHG emissions for the whole food system in the UK (both pre and post farm gate) range from 18% (Tassou et al. 2014) to 30% (Audsley et al. 2010) of the total emissions the UK produces.

In a vicious cycle, climate change also affects agriculture, leading to reduced yields or destroyed crops through increased or decreased water supply, changing temperatures, or changes in insects, pests and disease levels (FAO 2015c)[7]. Therefore, agriculture needs to both adapt to, and mitigate against, climate change, reducing the gases produced which could increase the risks of climate change (IAASTD 2009).

Current predictions of climate change in the UK range from increased temperatures of 'around 3°C in the south and 2.5°C further north' (Met Office Hadley Centre et al. 2011: 67) to a reduction in productivity of agricultural land in the eastern side of the UK due to reduced water availability, sea levels rising, increasing soil aridity and a loss of organic matter (The Adaptation Sub-Committee of the Committee on Climate Change 2017: 56) suggesting crops may be grown further north and west. However, a new set of climate projection models will be produced in 2018 which might revise those predictions (UK Climate Projections 2017).

[6] Those emissions which are produced after the agricultural produce leaves the farm (so emissions produced from processing, distribution and retail).

[7] It must be noted that there can also be positive consequences from climate change such as an increase in crop yields due to increase in CO_2 (DEFRA 2017c). This is discussed more in Section 2.2.5.

In the UK, various interventions are working towards encouraging agricultural change to mitigate or adapt to climate change. These are discussed in detail in Chapter 2, but are briefly introduced here. According to a recent Department of Environment, Food and Rural Affairs (DEFRA) and devolved government departments[8] report *Agriculture in the United Kingdom 2016,* agricultural land in the UK comprises 17.4 million hectares (71% of all UK land), which includes 508 thousand hectares farmed organically (DEFRA et al. 2017: 14). There are over 53,000 agri-environmental agreements in place in the UK, covering more than 6.8 million hectares across the UK (39% of the total agricultural land in the UK), which provide incentives for farmers to manage and adopt practices which help the environment (DEFRA et al. 2017). Since 2008, agri-environmental schemes (AES) have also included climate change adaptation and mitigation methods including changing land use, reducing GHG emissions and chemical inputs, planting trees and introducing or improving field margins and hedges which not only improve habitats for biodiversity but also can reduce pollution (Natural England 2009). In England, these include improving biodiversity, reducing nitrogen and phosphate usage to improve water quality, and improving soil organic matter (DEFRA 2015a). Given that since 2008, the AES now includes climate change adaptation and mitigation methods, they are an indication of farmers who may have begun to become more climate-resilient.

Currently, government funding for farmers includes measures to implement AES that would benefit the UK agriculture sector given the future of a changing climate. These have been guaranteed to continue until 2020 regardless of the UK leaving the European Union (UK Government 2016)[9]. However, those funds do not address the specific issue indicated by a recent UK Farm Practices Survey, that just under half of the 2300 farmers replying (49%) did not consider GHGs important to their decision

[8] Department of Agriculture, Environment and Rural Affairs (Northern Ireland) (DAERA); Welsh Assembly: The Department for Rural Affairs and Heritage; and The Scottish Government: Rural and Environment Research and Analysis Directorate.
[9] The impact of Brexit in the snapshot of time when this thesis was written up (June 2016-March 2017) is discussed further in Appendix 12

making on their farms (DEFRA and National Statistics 2017a). Furthermore, across all the ten indicators of GHG emissions[10] that were outlined in the Farm Practices Survey (which included overarching indicators such as mitigation, but also farm sector indicators) only the pig, dairy, poultry and cereals sectors showed clear improvement in status of the indicators (over the most recent 2 year period) (DEFRA and National Statistics 2017b).

The Greenhouse Gas Action Plan (GHGAP) is one of the main agricultural interventions and is industry led. It produces reviews every four years to assess how the agricultural industry tackles climate change by reducing the GHG emissions across six key areas (animal husbandry and improved health and welfare; livestock breeding – genetic improvement potential; soil and land management; crop nutrient / crop health management; management, skills, advice and guidance; and energy efficiency and renewables) (DEFRA 2017a). The target is to reduce GHG by 'at least 3 million tonnes of carbon dioxide equivalent per year (3MtCO_2e) by the end of the third carbon budget period (2022)' (DEFRA 2017a: 1) The most recent report assesses against the six areas and estimates that the agricultural industry achieved a 1MtCO_2e by 2016. However, it also acknowledges that to achieve the target by 2022, the GHGAP needs to be more pro-active in keeping the industry on track whilst increasing the uptake of mitigation methods, alongside encouraging the industry to develop new mitigation techniques and its own momentum to reducing GHG emissions (DEFRA 2017a).

Many of the different agricultural sectors within the UK have also produced roadmaps of what they want to achieve. The dairy industry for example, is aiming to reduce GHG emissions from dairy farms by 20-30% between 1990-2020, improve energy efficiency by 15% and reduce water usage by 20% by 2020 (AHDB Dairy et al. 2015).

[10] Ten indicators of the Farm Practices Survey: Attitudes & knowledge; Uptake of mitigation methods; Soil nitrogen balance; Pig sector: feed conversion ratio for fattening herd; Grazing livestock sector: beef and sheep breeding regimes; Dairy sector: ratio of dairy cow feed production to milk production; Poultry sector: feed conversion ratio for table birds; Cereals and other crops: manufactured fertilizer application; Slurry and manure; Organic fertilizer application (United Nations Framework Convention on Climate Change (UNFCCC) 2016b).

Other industry roadmaps include the cereals and oilseeds industry roadmap (HGCA 2012) and the three phased beef and sheep production roadmaps (EBLEX and AHDB 2010a, 2010b, 2012).

1.1.3 Agroecology and farmer behaviour in a UK context

Agroecology, was originally considered as the scientific discipline of agriculture and ecology (Wezel et al. 2009). Over time, it has evolved to include sustainable farming techniques such as organic and elements in agri-environmental schemes mentioned above such as planting trees. Similar to sustainable development, agroecology could be defined as considering farming's relationship with society, the economy and environment (Francis et al. 2003). In addition to farming techniques and practices, agroecology also encourages social movements to address political issues related to farming including food security (Fitzpatrick 2015). By exploring farmer behaviour, the barriers to changing agricultural techniques and the drivers to introduce methods that could create climate-resilient agroecological communities could be investigated. Agroecology and sustainable farming (AaSF) techniques may be a way for farmers to mitigate and adapt to climate change (Altieri et al. 2015) whilst sustaining their livelihood and feeding a growing population. Thus understanding the barriers to changing techniques might encourage farmers to begin to farm more agroecologically. Climate-resilient farming is defined as farming which can be resilient to, (that is withstand, adapt to, recover from and mitigate against) any impacts of climate change. In this thesis, AaSF techniques are the main farming practices discussed which are climate-resilient. However, it must be acknowledged that some techniques such as minimum tillage are also used by conventional farmers and can allow their farms to be resilient to climate change. This is discussed in detail in Chapter 2.3.

1.1.4 Sustainable livelihoods in the UK agricultural sector

Sustainable livelihoods explore how assets (social, human, natural, financial and physical[11]) can reduce a person's vulnerability to hazards, and enable them to access resources, thus sustaining their livelihood despite any challenges they may face. Despite this, the concept of sustainable livelihoods is not customarily applied to those who live in those countries that have higher incomes and are more industrialised. However, individual farmers do need an economically sustainable livelihood to remain in business (Ponder and Hindley 2009), whilst staying resilient to hazards, shocks and stresses. In the UK, these could be the impacts of climate change on agriculture, those long term effects such as increasing temperatures (Blunden 2017), and shorter term impacts such as excess flooding (Muchan et al. 2015), or other impacts such as farm losses from reduced yields or cattle with TB (Brooks-Pollock et al. 2014), or even financial stresses such as delayed subsidies (Daneshkhu 2016a). As a result, the analytical framework of this thesis (Chapter 3) uses the structure of sustainable livelihoods to build climate-resilient farming communities in the UK, through the exploration of agroecological practices on UK farms and agroecological behaviour change amongst farmers.

There is little research regarding sustainable livelihoods in the UK agriculture sector, even less using agroecology as a way through which farmers can withstand the shocks and stresses from climate related hazards: one study investigates sustainable agroecological livelihoods with regards to smallholdings (Maxey et al. 2011) whilst another community supported agriculture (CSA) (Saltmarsh et al. 2011). However, as farmers in the UK do still have the five assets listed at the beginning of this section[12], agricultural activities can improve or reduce those assets, thus increasing or reducing their resilience to hazards. There is UK research regarding other areas of farmer livelihoods such as farm diversification (McNally 2001, McElwee and Bosworth 2010,

[11] One example of explaining all these assets, uses the problem of poor soil fertility. Through a farmer gaining knowledge (human and social assets) to improve their soil (natural asset), their crop yield may improve (physical asset), potentially increasing the costs they would receive when selling that crop (financial asset).

[12] Social, human, natural, financial and physical

DEFRA and National Statistics 2016a), and falling farm incomes and these will be discussed with regard to sustainable livelihoods in the UK in Chapter 3.

By farming agroecologically, encouraging small-scale farmers to farm using organic inputs and to work with nature, adapting to and mitigating against climate change; rural livelihoods; the ensuing food security; and environmental sustainability may answer many of the above issues (Lappé and Collins 2015, IAASTD 2009). These are discussed more in Chapter 2.

1.2 Significance of the study

This thesis contributes to current knowledge regarding agroecology in the UK, and in what manner it is being used in the UK farming sector. It will also contribute to the application of sustainable livelihoods in the context of industrial regions and consider specifically farmer sustainable livelihoods, farmer behaviour and climate-resilient farming and how they all apply to a UK context. The intention is that papers emerging from it will be submitted for publication to provide information relating to these themes.

This research is also a contribution to farming and environmental organisations' research and extension programmes. These could be organisations such as the Soil Association, Farming Community Network (FCN), the All-Party Parliamentary Group (APPG) in Agroecology and ideally the National Farmers Union (NFU). The research will be shared with contacts at those organisations or though articles and papers submitted for publication.

Another intended outcome is by contributing in understanding of how agroecological and sustainable farming knowledge is currently shared and exchanged amongst farmers, with the increase in social media and accessible broadband, and how this can influence and encourage farmers to change. Those participants of this thesis who indicated an interest in the results will be sent a copy of this thesis's research; it will also be included in any of the aforementioned articles.

Finally, the thesis intends to inform thought processes concerning government farming policy over the next decade. This will be through further research and the submission for publication of papers that could potentially influence decisions.

1.3 Aim and research questions

1.3.1 Aim

To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities and livelihoods.

1.3.2 Research Questions

1. What are the characteristics of agroecological interventions for building climate-resilient farming communities and ensuring sustainable livelihoods for UK farmers?
2. What are the drivers and barriers to behaviour change in farmers towards using more agroecological practices to build climate-resilient farming communities?
3. What are the implications of such changes for the UK food system?

1.4 Structure and outline of the thesis

The research questions each build upon the last to address the aim across the whole thesis.

The second research question is explored in the theoretical framework of Chapter 2, which has the key themes of exploring hazards, barriers, resources, resilience and livelihood assets. It firstly examines the interactions between climate change and farming. This explores how climate change can influence agriculture causing shocks, hazards and stresses, yet agriculture itself also influences climate change. The chapter therefore discusses why agriculture needs to adapt and mitigate, and following that, the importance of changing farming systems to those that are more agroecological and climate-resilient. The chapter then explores agroecological and sustainable farming, techniques, and arguments for and against those styles of farming, before moving to consider changing the behaviour of farmers to use more agroecological techniques. This can be encouraged or hampered by drivers and barriers. The chapter ends by focusing on different agroecological interventions, thus addressing the first research question.

The third chapter combines research questions 1 and 2 by exploring sustainable livelihoods and how they link to agroecology and sustainable agriculture in the UK. The chapter then moves onto explore the Department for International Development's (DfID) sustainable livelihoods framework (SLF) and two livelihood frameworks adapted specifically for agroecology in different global contexts. Finally, the chapter considers in detail an alternative livelihoods framework that explicitly considers barriers, along with visually showing a whole farm and it's household at the centre of the framework. The chapter ends with an explanation of the adapted framework (Figure 3-1) revised for both the UK context and agricultural sector to help explore agroecological climate-resilient farming in the UK and how it can improve farmers' livelihoods.

Chapter 4 considers the data to be collected, which not only aims to meet all three of the research questions, but also expand on the theory from Chapter 2 and operationalise the analytical framework of Chapter 3. Beginning first with a brief explanation of methodological paradigms, epistemology and ontology, the chapter next explores the quantitative/qualitative debate and the emergence of mixed methods. The chapter then moves on to consider the research design, followed finally by a description of the data collection and analysis of the two phases (Phase 1 survey, Phase 2 individual and group interviews) and how they will progress to achieve the research questions.

Chapters 5 and 6 use the analytical framework (Figure 3-1) to analyse the Phase 1 and Phase 2 data accordingly, critically evaluating how they address all three of the research questions as well as providing practical answers to research question 1.

In Chapter 5, the quantitative and qualitative results from Phase 1 first are used to consider broadly the demographics of the survey respondents before teasing out hazards, the human and social assets of farmer learning, along with applying what they have learnt, followed by barriers to agroecological change (and where applicable, to accessing resources which can promote change). The chapter concludes by examining the significant themes that emerged from the data such as topics related to soil from soil carbon and soil root structures, to permanent pasture.

In Chapter 6, the qualitative results of the Phase 2 individual and group interviews are discussed. After an initial sweep of the data, the chapter follows a similar pattern, first exploring the hazards revealed including those related to climate change and UK weather. Partly through interview discussions of different interventions, the chapter then analyses, those assets related to learning and applying techniques. The chapter next investigates barriers to change, including tangible barriers such as those related to finances or lack of resources, along with those more intangible such as knowledge or sociological barriers.

Chapter 7 then draws the two results chapters together, whilst using the framework from Chapter 3 to critically evaluate the research questions. The chapter first considers hazards related to climate change and weather, along with other shocks, stresses or hazards. It then discusses each of the assets (social, human, natural, physical and financial) and how they build a farmer's resilience to the aforementioned hazards, followed by barriers and resources. The chapter then examines the key themes drawn from the data: those of the importance across most farming sectors of a healthy soil; the rise in peer-to-peer knowledge exchange between agroecological farmers isolated by geography but connected over what this thesis identifies as an "electronic hedge" of video, email and social media; and the importance of considering the non-physical barriers to change from a farmer's beliefs to educational barriers. The chapter concludes by discussing the limitations to the thesis, those related to the methods used, and those related to the analytical framework.

The thesis concludes with Chapter 8, that recapitulates the thesis, explores if the research has met the aim and research questions listed in 1.3 above, considers key themes that have emerged from the two results chapters and the discussion chapter, before concluding by suggesting recommendations and future research.

1.5 Summary

This chapter has introduced the justification for the research along with a brief background of the broader issues of climate change, agroecology, and sustainable livelihoods with the focus on the UK farming sector.

It then considered the significance of the study, along with the aim and research questions, which as mentioned above, will be reflected upon at the end of the thesis. The chapter finally introduced the structure of the thesis and how it all connects back to the aim, research questions, and theoretical and analytical frameworks.

Chapter 2 – Theoretical framework

2.1 Introduction

In this chapter, a theoretical framework for the research will be given with a diagrammatic version at the end of the chapter as Figure 2-3. It is derived from relevant literature, and justifies the research aim and research questions, which were introduced in Chapter 1. It also acts as a basis for the conceptual thinking undertaken in Chapter 3 and underpins the discussion of the implications of the primary research in Chapter 7.

Examining peer-reviewed articles, books, conference articles and reports from Government and Non-Governmental Organisations (NGOs), this chapter expands from the justification in Chapter 1. It first examines the relationship between climate change and farming; the impacts each have on the other; and adaptation and mitigating methods of climate-resilient farming. The chapter then explores agroecology and sustainable farming with a discussion of meanings behind agroecology and sustainability, before considering common farming techniques for those practices and how they relate to climate-resilient farming techniques (including permaculture and holistic management), along with those farmers transitioning to agroecology. The chapter then investigates what might motivate a farmer to alter their farming techniques, exploring behaviour change on UK farms in relation to building climate-resilient farming communities and livelihoods. This includes examining farmer resilience to climate change through the building of their livelihoods, along with barriers to change. This section of the chapter then lastly discusses behaviour change which could help with engaging farmers.

The chapter ends by investigating agroecological and sustainable farming interventions that already exist in the UK, from government policies and research, to alternative farming organisations such as the Soil Association, Regenerative Agriculture UK, carbon calculators and website interventions.

2.2 The relationship between climate change and farming

2.2.1 Climate change

The Intergovernmental Panel on Climate Change (IPCC) defines climate change as:

> 'a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity' (IPCC 2007: 30).

Globally, over time, the production of GHGs has caused global temperatures to increase; between 1880 and 2015, the average annual global temperature has increased by 0.87^{o}C (NASA 2015). Furthermore, 2014, 2015 and 2016 were the three hottest years on record (Mann et al. 2017), and January to August 2016 where the highest on record (World Meteorological Organization 2017). Even within the UK, excluding April and November, 2016 was the warmest on record (Kennedy et al. 2017). Admittedly, there has also been a particularly strong El Niño in the early months of 2016, but meteorological organisations state that global land and ocean temperatures continued to remain warmer than average (NOAA National Centers for Environmental Information 2017). This has led to impacts such as changes in precipitation including (in the UK) a predication of greater intensity of rainfall and higher monthly totals of rainfall in winter (Committee on Climate Change 2017a); melting of glaciers; negative impacts on crops yields due (in the UK) to issues such as lack of water, aridity of soil and flooding from rising sea levels (The Adaptation Sub-Committee of the Committee on Climate Change 2017); increases in heat related human ill-health; and extremes in climate-related events such as droughts, cyclones and wildfire (IPCC 2014a). A more detailed discussion of elements affecting the UK agriculture and analysis of the impact can be read in 2.2.3 below.

Since the 2007 statement above, the IPCC have acknowledged 'It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century' (2013: 15). Despite this apparent certainty, some still debate whether or not the climate is changing and how much of that is the result of human activities (Bain et al. 2012, Capstick and Pidgeon 2014). This is regardless of the fact that the climate has changed due to natural changes in the weather and planet (Hulme 2009) and that the consensus of 97% of climate scientists is that human activity has caused the climate to warm more than it would otherwise have, and therefore to change (Cook et al. 2016, 2013). In addition, the consensus extends beyond climate scientists to biophysical scientists who also believe that human activity has contributed to raising global temperatures (Carlton et al. 2015).

In 2015, world leaders developed the Paris Agreement acknowledging that governments, society and individuals need to address and mitigate against climate change and work towards keeping global average temperatures significantly below 2°C and to attempt to keep it below 1.5°C (United Nations Framework Convention on Climate Change (UNFCCC) 2016a)[13]. The Paris Agreement came into force on the 4th November 2016. By January 2017, 127 countries had ratified the treaty (UNFCCC 2017). However, current estimates based on the Intended Nationally Determined Contributions[14] of all countries across the globe suggests that we are unlikely to meet the 2°C, let alone the 1.5°C and instead are more likely for the globe to warm up by 3.4°C (UNEP 2016), so greater action to cut emissions needs to be undertaken across the world.

Adaptation and mitigation have different meanings and interpretations. The IPCC define adaptation to climate change as practices, techniques and initiatives that will reduce biological and human system vulnerabilities to climate change (Baede et al. 2007) and thus increase resilience. They define mitigation against climate change as policies and practices which reduce GHG emissions and improve carbon sinks, such as

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[13] The Agreement was opened for signature in April 2016 and 'will enter into force 30 days after 55 countries that account for at least 55% of global emissions have deposited their instruments of ratification'(Levin et al. 2015, UNFCCC 2016).
[14] These are reports submitted by each country to the UNFCCC to state their domestic preparations and commitments post 2020 to reduce emissions and address climate change (IPCC 2000: 5).

those locked in peat bogs, or in soil (Baede et al. 2007), thus potentially reducing the impact of climate change[15]. Whilst extreme climate change could still be reversed through carbon sequestration in soil and reduction of emissions (IPCC 2014b), the authors of the fifth assessment report for the IPCC do acknowledge that without additional mitigation efforts (along with adaptation and emissions reductions), warming and other impacts of climate change related to warming are likely to continue. Given that any mitigation efforts or reduction in emissions that occur now are unlikely to stabilise the climate and its impacts, and instead would merely reduce the impact for the mid to latter half of the 21st Century, some climate change effects are already likely to occur over the next two decades (IPCC 2013, European Environment Agency 2017). NASA scientists estimate that considering current technology and knowledge, some impacts of climate change are already too far developed to be reversed (Tenenbaum and Miller 2013). An increased occurrence of extreme events is likely in the UK as the climate changes. Certainly, scientists at the UK Met Office have agreed that human influence on climate change has increased the probability of events such as unseasonable warmth during UK winters such as the 2015-16 winter (Stott et al. 2016), extreme sunshine hours in the winter 2014-15 (Christidis et al. 2016), along with increasing global annual average temperatures (McCarthy et al. 2016, Mann et al. 2017). They also found that extreme rainfall lasting about ten days in UK winters showed evidence of human influence (Christidis and Stott 2015).

However, not all impacts will be negative. Scientists have found that some crops will increase their yields with an increase in CO_2 and use less water (Deryng et al. 2016). Furthermore, as the global temperature increases, parts of higher latitude countries will be better suited for growing crops (Porter et al. 2014). Iqbal and Arif (2010) predict mountainous areas of Pakistan would increase wheat yields, although the growing

[15] Both climate change adaptation and mitigation are of interest to this thesis and the techniques discussed in both Sections 2.2.4 and 2.3 encompass techniques which relate to both adaptation and mitigation.

season itself would shorten whilst Trnka et al. (2011) using the SRES-A2 scenario (IPCC 2000) calculated to 2050[16] suggest that crop production in Europe could expand northwards as the temperatures increased. The authors also discuss the point that as the summers get drier for most of Europe, only northern European regions including Finland and parts of Russia will be suitable for rain fed crop production (Trnka et al. 2011). The IPCC however, state that the reduced quality of soil nutrients and the lack of suitable infrastructure to convert previously unused land to productive arable land hinders estimates of the suitability of future cropping land (Porter et al. 2014). Moreover, the IPCC also predict an increase in weeds, plant pathogens and insect pests in previously colder Northern European countries, which will impact negatively on crops (Kovats et al. 2014), whilst other regions such as Canada and parts of the USA may face reduced water availability and soil moisture (Romero-Lankao et al. 2015). As a result, looking globally, negative impacts on food production vastly outweigh positive impacts from climate change (IPCC 2014a).

2.2.2 Farming's impact on climate change

Smith et al. (2014) state that, across the globe, agriculture accounted for '10-12% of total global anthropogenic emissions' of GHGs. However, unlike other sectors, for the agricultural sector, this assessment consists of non-carbon dioxide emissions (CH_4 and N_2O respectively which are both more powerful GHGs than CO_2[17]) as agriculture's CO_2 emissions are seen as carbon neutral because they are associated with carbon fixation and photosynthesis (2014: 822). Any CO_2 emissions from farm machinery are not counted with agriculture, forestry and other land use activities for the IPCC report and

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[16] The SRES-A2 scenario is one of four scenarios developed by the IPCC to assess different directions for future developments up until 2100. The A2 describes a heterogeneous world with self-resilient people preserving local identities. However, the global population is continuously increasing, economic development is orientated by region, and technological change and economic growth per person are more fragmented than other scenarios (IPCC 2014c).

[17] N_2O is 265 times and CH_4 28 times more powerful than CO_2 as GHGs (Agricultural Industry GHGAP Steering Group 2011). These figures are often shown as CO_2e, which is the equivalent amount of CO_2 to have the same potential of causing global warming (IPCC 2014c: 132). The IPCC use CO_2-eq. instead, with the same meaning (DEFRA and National Statistics 2017b). However for the sake of this thesis, a combination of the two will be used, that is CO_2eq.

are instead considered in the IPCC *Fifth Assessment Report's* energy chapter[18] (Smith et al. 2014). When looking globally at the total of non-CO_2 emissions created from human activity (anthropogenic), the agriculture sector contributes the greatest amount of global anthropogenic total non-CO_2 emissions recorded at 54% of CH_4 and N_2O emissions in 2005 (Office of Atmospheric Programs - Climate Change Division 2012).

The current UK figures submitted to the UNFCCC estimate that in 2014, agriculture contributed approximately 8.7% of the UK total of GHG emissions, which consisted of 35% of N_2O and 61% of CH_4 and 3% CO_2 (Brown, P. et al. 2016: 108).

However, these figures are estimated and can vary depending on the report as shown in Table 2-1 below:

Table 2-1: 2014 Figures for UK GHG emissions from agriculture

Author	**Report**	**% of total UK GHG emissions**	**Proportion of total from N_2O**	**Proportion of total from CH_4**	**Proportion of total from CO_2**
(Brown, P. et al. 2016)	GHG inventory report to UNFCCC, page 108	8.7%	35%	61%	3%
(DECC 2016)	UK GHG emissions, Final Figures for 2014, page 21	9%	33%	56%	11%

DEFRA's report *Agricultural Statistics and Climate Change 8th Edition* has agriculture producing 10% of the total UK GHG emissions, but their report does not break down

[18] Chapter 7 of Working Group three's Climate Change 2014: Mitigation of Climate Change.

the percentages of individual gases in the same manner so therefore cannot be directly compared to the other two reports[19] However, when looking at the million tonnes of CO_2 equivalent figures rather than the percentages, both DECC's and DEFRA's 2016 reports have the same estimated figures with total emissions at 49.1 $MtCO_2eq$, N_2O emissions at 16.3 $MtCO_2eq$, CH_4 emissions at 27.4 $MtCO_2eq$ and CO_2 emissions at 5.3 $MtCO_2eq$ (DECC 2016: 21, DEFRA and National Statistics 2016b: 15)[20].

The main sources for methane and nitrous oxide are mainly from animal enteric fermentation (CH_4) and fertiliser use (N_2O) (DECC 2016). However, in the most recent GHG inventory for the UK, the Committee on Climate Change (CCC) breakdown the agricultural sector's emissions with enteric fermentation at 49% of the emissions, soils (including fertiliser use) at 29%, management of livestock waste and manure at 11%, mobile and stationary machinery at 10% and other sources[21] of emissions at 1% (Committee on Climate Change 2017b). Despite the largest emissions coming from the livestock sector, the different sectors amongst the UK agricultural scene have developed roadmaps to reduce their GHG emissions (as discussed in 1.1.2). These will help reduce the total GHG emissions from agriculture from livestock, arable and other individual sectors (DEFRA 2017a).

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[19] The three individual gases are shown as the percentage of that gas that agriculture produces in total, so the N_2O percentage is for all N_2O emissions in the UK (at 71%) rather than a proportion of the 10%. CH_4 is shown at 53% of the total UK methane emissions and 1% of the total CO_2 emissions (DEFRA and National Statistics 2017b: 15). Technically, they should therefore not be compared to the other two sets of figures. However, if they were to be compared, similarities and differences can be seen when the three sets are viewed together. This is important because whilst the Brown et al. report and the DECC report show CH_4 as gas with the most emissions emitted by agriculture, the DEFRA figures obscure that by showing N_2O as the greatest emitted. Farmers viewing these figures could therefore get confused and this could add to the barrier between research and academic knowledge and practical knowledge (which is discussed further in 2.4.2 below).

[20] DEFRA and National Statistic's 8th edition of agricultural statistics and climate change revise these estimations a little with CH_4 at 27.7 $MtCO_2eq$ and CO_2 at 5.2 $MtCO_2eq$ instead (Committee on Climate Change 2017b).

[21] These include non-fuel emissions of N_2O and applications of lime from limestone and dolomite (Peterson et al. 2012, 2013, Herring et al. 2014, 2015, 2016, Kennedy et al. 2017).

These GHG emission figures do not include indirect emissions such as CO_2 or other gases which are produced from transporting and processing food beyond the farm, fertiliser production, or importing food into the UK from other countries (Audsley et al. 2010). For agriculture, with the focus on reducing its impact on the climate, mitigation of CH_4 and N_2O GHG production needs to be considered equally alongside CO_2 mitigation (both of which are discussed below).

2.2.3 Impacts of climate change on farming

Predictions suggest that as the climate changes, increased temperatures could affect global agriculture. Agriculture could also be affected by changes in rainfall patterns; shrinking glaciers; rising sea levels and/or flooding; and more extreme weather, which could see changes in growing seasons, increased evaporation and water shortages along with prolonged droughts, and changes to insect populations (Gornall et al. 2010). Many of the impacts on agriculture are the result of environmental change over time change and may only be fully observed after a number of years. Glantz et al (2009) point out that when a drought causes crops to fail, that is clear for anyone to see. However, when crop yields decline over time (for example due to soil deterioration), that is less noticeably detected (Glantz et al. 2009: 28).

The world has begun to notice both the immediate impacts and those predicted to occur. Since the turn of the century, globally there have been signs of climate affected agriculture, such as increased soil salinity from rising sea levels in Bangladesh (Hossain 2010, Rasel et al. 2013) and reduced rainfall, shrinking glaciers and drought conditions in East Africa (WMO and UNCCD 2011, Mulangu and Kraybill 2013, Adhikari et al. 2015). Within the UK, there have been periods of extreme weather (from weeks to months) based on the definitions of climate and weather (in the list of definitions) which could be seen as an example of a changing climate (Met Office Hadley Centre 2016a, NASA 2005)[22]. Between 2010-2012, the Environment Agency classed much of

[22] Furthermore, between the UK and global community of meteorological and climate scientists, reports and articles have been produced which discuss the extreme events of the previous year from the perspective of climate change (Kendon et al. 2017).

England and Wales as having drought conditions which impacted on agricultural crops for two years (Kendon et al. 2013), and this was then followed by flooding which whilst initially welcomed by the agricultural sector, soon became problematic by reducing crop yields (Parry et al. 2013). Over the 2013-14 and 2015-16 winters, the UK faced extreme flooding, first in the Somerset levels and South-West (Muchan et al. 2015), and then in the north of the country (McCarthy et al. 2016), both of which caused significant impacts to agriculture, either through the loss of livestock, or flood damaged land (Rural Payments Agency and DEFRA 2016). According to the UK Met Office, December 2015 was the warmest on record which was partly responsible for the excess flooding in the north (2016b, McCarthy et al. 2016). With the warmest months on record occurring globally[23] throughout 2016 (Kennedy et al. 2017), more unusual weather may also occur in future years. The fact that each of the above UK examples took place for longer than one week and broke climate records, suggests that they are certainly examples of extreme weather and a changing climate even if they are not directly influenced by anthropogenic climate change (Wild et al. 2015, Christidis and Stott 2015). Certainly increased temperatures and an increase in sunny days in the UK can be attributed to human influenced climate change (Christidis et al. 2016, King et al. 2015), whilst extreme precipitation is harder to connect to climate change with current climate modelling (Stott et al. 2016).

The UK Government and the CCC have updated their 2012 climate change risk assessment for 2017, and include a chapter on the natural environment (along with the associated evidence report) which contains climate impacts on agriculture including those in relation to soil, land availability and capability, and crops and livestock (Committee on Climate Change 2017a, Brown, I. et al. 2016). Examples of the predicted risks (and potential gains) to UK farming can be seen in Table 2-2 below.

[23] It must be noted that 2016 was only the 13th warmest on record for the UK, but had great extremes with April 2016 being among the top ten coldest, whilst September and December 2016 being among the top ten warmest (de Ruiter 2016).

Table 2-2 Showing potential risks (and gains) for agriculture from climate change (where not specifically mentioned references refer to (Brown, I. et al. 2016)).

Soil	Land availability and suitability	Crops	Livestock
Reduction in soil moisture in the East of England across majority of climate projections	Increase in droughtiness and aridity of agricultural land to the Eastern side of the UK (Keay et al. 2013)	Shift in production to new locations further west or north or at different times in the year due to longer growing season and milder winters. Current wheat varieties are flowering earlier and being harvested earlier with warmer temperatures	Extended grass growing seasons enabling outwintering of livestock (SAC Commercial Limited and Institute of Biological Environmental and Rural Science 2014), however warmer and drier summers could also restrict grass growth in the East of the country.
Erosion of soil by up to 150% if winter rainfall in wet years increases by 10%	Increased risk of river, coastal and surface flooding across the UK from 570,000 ha of land in 2015 to 656,000 ha in 2050 under a 2^{o}C rise in global mean	Potential increase in crop yields due to warmer temperatures (Olesen et al. 2011, Moore and Lobell 2015) or due to CO_2 fertilisation (if no problems with lack of water or nutrients) (Brown, I. et al. 2016)	Dairy cows could experience heat stress from one day a year (currently) to 20 days a year by the end of the century (Dunn et al. 2014). Heat stress will also affect animal welfare for pigs and poultry who have trouble

	temperatures[24] (Sayers et al. 2015)		thermoregulating (Moran et al. 2009)
Risk of localised soil compaction in the wetter climates of Wales, South-West and North-East England, West Scotland and Northern Ireland	Improvement in the quality of agricultural land in the north and Scotland (Brown, I. et al. 2016)	Reduction in water availability impacting yields of potatoes (Daccache et al. 2012) and droughtiness and lack of water reducing crop yields.	Increased temperatures or rainfall could increase pests, parasites and disease such as liver fluke which could harm livestock and red mite which harms poultry, and more exotic diseases such as bluetongue and Schmallenberg virus (Skuce et al. 2013)

With regards to climate risks to crops, the CCC evidence report does note that impacts from climate change are noticeable during extreme weather (both bad and good), whilst for years without extreme weather socio-economic factors including technology improvement are the main impact on crops (as shown by the increase over 20 years in strawberries grown in the UK) (Brown, I. et al. 2016).

[24] More frequent that 1 in 75 years (with a risk of even greater areas of land flooded with higher temperatures).

These predictions do not take into account where climate change may impact on global trade, business and industry which indirectly could also affect agriculture. One example given in the CCC evidence report on international dimensions was of the 2012 US drought which increased the price of soyabeans (used in livestock feed) thus impacting on the UK pig industry (Challinor et al. 2016). Thus agricultural mitigation and adaptation to climate change will become important to build resilience against impacts.

Whilst agriculture within the UK may be able to adapt to the impacts of climate change in the near future, it is imperative that the farming industry works to further to mitigate against climate change by reducing its outputs of GHGs which would benefit not only the UK, but also the world.

2.2.4 Agriculture's potential for adaptation and mitigation

For the UK, by 2030, the CCC estimate that agricultural emissions could be reduced by 8.5 $MtCO_2eq$ (Committee on Climate Change 2015: 171) which would translate to approximately 17.3% mitigated of the UK's current agricultural GHG emissions. Eory et al. in their detailed report on GHG abatement potential, estimate that by implementing cost effective measures, agricultural emissions could reduce in 2030 by between 0.53-6.99 $MtCO_2eq$ depending on policy scenarios which include information policies, financial incentives (and disincentives), to more stringent policy regulations (2015: 14–15). These translate to between 1.08-14.2% saving of the UK's current agricultural GHG emissions. Both reports include soil and crop mitigation measures as part of the figures. Whilst these figures are not high, it must be acknowledged that neither is the agricultural GHG emissions of the UK high with an average percentage of the total UK GHG emissions from Table 2-1 of 9% in 2014. However, despite only small margins to be gained in mitigating agricultural emissions, it is still important for those emissions to reduce (alongside other industries that have higher emissions).

Following the definition of adaptation and mitigation in 2.2.1 (and in the definition section at the beginning of this thesis), this section looks at a range of agricultural principles and methods which have the potential to mitigate against climate change and adapt to its impacts, such as sequestering carbon in the soil; reducing chemical fertilisers and introducing natural nutrients from crop rotation and cover crops; the potential to adapt arable crops, considering animals and their food and their waste; renewables and farm maintenance. These are all discussed below.

Managing soil to reduce carbon loss and sequester carbon to potentially mitigate climate change

Soil is the biggest sink of carbon. Carbon is naturally locked in the ground, and whilst carbon stock concentrations of arable land are not particularly high compared to forests, grasslands and wetlands such as peat land which have been undisturbed for many centuries, any carbon that is locked in the ground is likely to be released when the land is disturbed (Ostle et al. 2009). If this is because of a change in land use, say, from deforestation for agricultural land[25], this is likely to not only release carbon, but also prevent the trees from capturing CO_2 in the future, and also possibly degrade the soil (Lal 2004a). However, Audsley et al. note 'that deforestation of the UK to supply agricultural land has taken place over millennia and much reforestation occurred in the 20th century. The associated CO_2 emissions from this historical deforestation have long been assimilated into the Earth's atmosphere' (2010: 11)[26]. Schwartz summarises Lal's 2004 articles (Lal 2004a, 2004b) stating that he estimates that 'the world's cultivated soils have lost between 50 and 70 percent of their original carbon stock, much of which has oxidized upon exposure to air to become CO_2' (Schwartz 2014). Carbon can also be released by leaving the soil bare for periods of time (which then becomes susceptible to erosion and the loss of nutrients), and by the intensive ploughing of the soil which, through aerating the soil breaks up and disturbs the soil organic matter (Lal

[25] Which admittedly is less likely in the UK

[26] Although this does not consider land use change in other parts of the world, where land is changed from forests, or other long term carbon storage, to cultivated land for crops, which are then sent back to the UK (Cooper et al. 2016).

2011, Lal et al. 2011). It is estimated that the technical potential of sequestrating carbon in the soil globally is approximately 2.1 billion tons C/yr (Lal 2011). The IPCC, in a more specific figure of CO_2 equivalent and per hectare of land, state that the technical mitigation potential by geographical area of carbon sequestration in soil is greater than 10 (tCO_2 e/ha)/yr (Smith et al. 2014).

Farming techniques to manage soil appropriately could help increase carbon sequestration in soil, thus mitigating GHG emissions and potentially reduce climate change (other mitigation methods are more suitable for damage mitigation to reduce impacts of the changing climate).

There are various farming techniques to mitigate against carbon release from the land, with the key elements to reduce soil organic matter loss, add soil organic matter to the soil, maintain the levels of soil organic matter and conservation agriculture. One way to reduce the disturbance of the ground and the soil organic matter is to use minimum or zero tillage[27] instead of ploughing. There are differing opinions on whether this merely reduces the carbon released; increases 'soil carbon gain'; affects N_2O release (Smith et al. 2007); or actually improves soil health, but with only small amount of GHG sequestered (Powlson et al. 2014). However, it has been noted that minimum tillage reduces the time and fuel a farmer spends ploughing their field, and therefore reduces the emissions released from any vehicles used (Lawson and Bullock 2007). Another way to mitigate is to plant a cover crop such as red clover on the fallow land, which will stop erosion and leaching (Ciais et al. 2013), maintain soil organic matter and can fix nitrogen in the soil, thus reducing the need for a nitrogen fertiliser (Rees et al. 2013). A third way, is to convert the land back to its original use, such as forest, grassland or even wetlands (Smith et al. 2014). This is unlikely to be popular amongst farmers when

[27] Minimum tillage in this thesis is defined as avoiding disturbing and inverting the soil and destroying the structure of the soil organic matter, thus tilling shallower than from conventional ploughing or turning the land (Wadsworth et al. 2003). There are various different types of minimum tillage including direct drilling, conservation tilling, and shallow and deep tillage without inversion (Friedrich and Kassam 2012). Zero tillage is defined as that which avoids tilling the soil altogether, although again there are different interpretations from creating small slots to plant seeds, to not using any mechanical tillage machines (Massé et al. 2011).

there is limited land suitable for growing crops, as it will reduce a farmer's yield. Furthermore, it may not be possible to determine what the original use of the land was. Instead of converting the whole field, alternatively, they could convert strips such as the edges of a field (field margins), or along waterways. However, if the yield could be increased, it would not only reduce the amount of land the crops needed to grow on, but also, each plant would lock more carbon into the soil, therefore increasing the possibility of mitigation (Bellarby et al. 2008). These techniques have been promoted within the UK by Nuffield Scholars who spent their years of scholarship studying certain farming issues (Richmond 2011, Walston 2015) and then shared with other farmers during farm walks (Farm Carbon Cutting Toolkit 2016), where the techniques were examined and discussed to assess how successful they were on that farm.

Conservation agriculture encompasses many of the techniques listed above from cover crops, to minimum to no tillage (Lal 2015). However, it also includes keeping the soil covered through keeping remains of crops as mulch on the surface, and rotating crops, which also improves water storage in the soil, and reduces soil erosion (Hobbs and Govaerts 2009). It has also recently been in a Farmer's Weekly news article as part of their month of promoting good soil health (FW Reporter 2017).

Soil and crop nutrition potential for mitigation

Crops require nutrients to grow healthily. Frequently, especially in conventional agriculture, this consists of fertilisers containing nitrogen, which emit CO_2 emissions during manufacture. GHGs are also released as N_2O when there is surplus nitrogen left over after the crops have absorbed what they need (Smith et al. 2007). As a result, mitigation methods need to reduce emissions or avoid them if at all possible. Techniques for reducing or avoiding emissions include monitoring the crops and only applying the nitrogen that is specifically needed at the required time (known as precision farming[28]) (National Farmers Union 2015a). Whilst chemical fertilisers are not used in organic farming, other nutrition methods including green manures, leftover

[28] Which admittedly is a technological and advanced way of managing crop nutrition.

crops and manure stockpiles can still release N_2O and therefore need to be managed carefully. Another method of ensuring crops gain enough nutrients to grow (but avoiding unnecessary application of nutrients, is to rotate crops between fields, planting nitrogen fixing crops such as legumes (as mentioned above). As these possibilities reduce the need for costly nitrogen fertilisers, Hillier et al. (2009) suggest that it would most likely make economic sense for farmers to use less chemical nitrogen inputs and instead employ cover crops, or biological nitrogen fixation. However, the authors go on to mention that even farmyard manure (FYM) can reduce the input of external non-biological nitrogen, and therefore farms that mainly use those, release less nitrogen that can convert to GHG. For arable farmers without livestock, they would have to purchase either seeds for the cover crops or FYM which may not be a choice some farmers are willing to make. However, as this also improves the health of the soil (and reduces soil degradation), it might be a cost some would consider. This is discussed more in the data collection and analysis in Chapters 5-7.

In the UK as part of the GHGAP farmers are being encouraged to develop nutrient management plans to reduce their GHG emissions (DEFRA 2017a), which have include planning fertiliser and manure applications using recommendations to optimise the supply from all sources of the nutrients and avoid applying when crops are less likely to take up the fertiliser (such as during frosts and excess rain) (Agricultural Industry GHGAP Steering Group 2011).

Adapting arable crops

In their chapter on *Food Security and Adaptation to Climate Change: What Do We Know?*, Lobell and Burke (2010) list potential adaptations farmers could introduce, including expanding into new areas to grow existing crops, to shifting dates for planting existing crops. However, they also acknowledge potential problems with their suggestions, with expanding into new areas potentially suffering from difficulties such as poor soils, or a lack of infrastructure, whilst shifting planting dates only really works for cooler climates and is less likely to be successful in the tropical regions where the growing season will shorten (Burke and Lobell 2010). Unlike adaptation issues such as reductions in growing seasons mentioned by Lobell and Burke above, currently, UK farmers have the advantage of adapting their farming methods to suit the changing climate as listed in Table 2.2, such as moving crops west and north in the country, or growing new crops which previously would not grow in the UK climate, for instance planting more maize, sunflowers, or even soya beans (Gornall et al. 2010). Some farmers have already begun to successfully grow olives (Olio of Oxney 2016), and others pecans; apricots; almonds; grapes; guava; and kiwi (Diacono 2014). However, other farmers have lost crops due to flooding (Parry et al. 2013) over the last few years, so adaptation techniques need to also sit alongside techniques to mitigate flooding in areas of the UK where flooding arable land occurs. Smith cautions that if current grassland was converted for arable crops, there would be the potential to lose 14 $MtCO_2e$ per year (Smith 2012), therefore it is also important for farmers to mitigate against climate change (as discussed in the previous two sections regarding soil and nutrition), working to reduce GHG emissions which would raise the global temperature above 1.5°C.

Livestock adaptation and its potential for mitigation

Farm animals, as discussed in Table 2.2 can suffer from climate impacts, from increasing temperatures and flooding, to increased pests. Adapting to these impacts would become important if the UK climate continues to warm. This could include better designed buildings to keep animals cool (without resorting to air conditioning unless powered from renewable energy), but this would require additional expenditure to erect the buildings or install air conditioning (Moran et al. 2009).

Farm animals produce GHGs: 'The basic principle throughout is that animals emit methane (ruminants) and produce manure which results in release of further methane and N_2O (all livestock) from the day they are born to the day they die' (Gill et al. 2010: 328). Ruminant livestock (sheep and cattle) emit considerably more CH_4 than non-ruminants or monogastrics such as poultry or pigs (Henderson et al. 2017). The release of CH_4 can be reduced by diet changes for ruminant animals, which also can improve productivity and reduce N_2O emissions from manure (Wollenberg et al. 2016). Liquid manure produces more GHGs than dry manure. So, whilst intensive farming can, within reason, collect the manure and store it; for animals grazing in fields, it is less efficient for a farmer to collect the manure as it breaks down into the soil producing less GHG than manure stored on concrete that is converted to slurry (Misselbrook et al. 2002, Petersen and Sommer 2011). However, slurry stores can be covered, which can reduce emissions (Petersen and Sommer 2011). Furthermore, with good grazing management of the livestock in the field, the lack of fertiliser applied to improve grass growth instead relying on animal manure, can improve carbon sequestration and thus soil and grass quality (Henderson et al. 2015). However, where the farmers can collect the manure (liquid or solid), there are significant advantages to treating manure via anaerobic digestion[29], such as reducing GHG emissions, generating energy and producing more efficient fertilisers which match crop requirements (Massé et al. 2011).

There is also the suggestion that if the general population changes their diet to eat less red meat, then that would reduce GHGs, as fewer animals would be required as demand dropped (Wellesley et al. 2015). However, this is argued against by Gill et al. who look at livestock from not only a GHG perspective, but also a food security perspective and point out that 'most of the diet of pigs and poultry is human-edible, whilst most of the diet of ruminant livestock (grass and forage crops) is not human-edible' (2010: 320). Therefore, switching to monogastric animals instead of ruminants could possibly affect global food security. This is also relevant in that whilst some grasslands could be converted to crop lands, that would release carbon into the atmosphere (as described in the previous section), and degrade the soil quality. Currently it is extremely hard to plant and harvest crops on steep slopes in the UK,

[29] There are some issues with anaerobic digestion, such as the cost of the purchasing and running the plant which would hinder its uses in the UK without government support through grants, or a collective of farmers forming a cooperative to pay for the costs, and reap the benefits (RegenAG UK 2014a, Collins and Doherty 2009).

which is where many of the cattle and sheep reside (Herrero et al. 2011). Garnett (2014) also cautions on the switch from red meat to either white meat, or tofu and soy as switching in either of those directions would require more land that is arable and possibly lead to further deforestation. Instead, 'a broad-based switch to plant based products through simply increasing the intake of cereals and vegetables is more sustainable' (Audsley et al. 2010: 6). This could be encouraged internationally or in the UK through promoting balanced diets, healthy eating, or meat free days in the mainstream media as well as with the governments, civil society, business and the science communities (Wellesley et al. 2015), but if farmers need to produce for market demand (to gain their income) and people continue to demand red meat, this could be problematic.

Managing waste, technology, renewables and maintenance for mitigation and adaptation

Smith et al. state: 'Recycling of agricultural by-products, such as crop residues and animal manures, and production of energy crops provides opportunities for direct mitigation of GHG emissions from fossil fuel offsets' (Smith et al. 2007: 532). However, they go on to point out that there are still some economic and technological barriers to utilising agricultural waste and by-products for general energy consumption. The technological barriers are slowing being resolved, such as an anaerobic digestion plant that can still create biogas and fertiliser for use on the farm or to sell to other farmers, and can digest the farm's food waste too (Massé et al. 2011), but as discussed in the livestock adaptation and its potential for mitigation section footnote 29 (page 31), the economic barriers of this can still hinder adoption by farmers). However, in the most recent review of the GHGAP, anaerobic digestion use has increased by 5% since 2012 (DEFRA 2017a). Another way to create renewable energy is to invest in wind turbines, or photovoltaic (PV) panels. As these require an initial cost outlay, some farmers are forming co-operatives, or consortiums to share the profits. If they are placed in fields with animals, they do not even interfere with the growth of crops (Spanner 2011).

As a consequence of the UK Government's feed-in tariff which started in 2010 (Ofgem 2010) providing income for any renewable energy produced, farmers have been encouraged to take up renewable energy projects (Macalister 2012). According to AHDB Dairy, in 2015 up to 15% of dairy farmers were using renewable energy (AHDB Dairy et al. 2015), whilst the NFU suggest that 60% of solar power comes from farmers and growers, and farmers own or host 2500 medium sized wind turbines (NFU 2017). However since 2015, the tariffs have been cut for new applicants and farmers who had begun to plan to build a renewable energy scheme on their farms faced receiving little to no income once they were up and running, leading to a significant reduction in farm renewable energy schemes (Spackman 2015a).

The steering group for the Agricultural Industry Greenhouse Gas Action Plan (GHGAP) (2011: 10) also suggests maintaining and repairing vehicles, equipment and buildings (including improving insulation of structures) to ensure everything is working to optimum efficiency and therefore not using extra fuel.

Using all the above methods according to suitability

Both Bellarby et al. (2008) and Audsley et al. (2010) state that whilst each of the above methods will reduce GHGs, to achieve the optimum reduction in GHG emissions, agriculture needs to combine the different measures to best suit their farms, but also to best suit the reduction in GHGs. The steering group for the GHGAP (2011) imply agreement with this analysis, suggesting positive changes and management improvement for all areas of on-farm activities.

> 'Mitigation of GHG emissions associated with various agricultural activities and soil carbon sequestration could be achieved through best management practices, many of which are currently available for implementation. Best management practices are not only essential for mitigating GHG emissions, but also for other facets of environmental protections such as air and water quality management' (Smith et al. 2007: 531).

As these techniques help build climate-resilient farming, farmers can benefit from adopting those which suit their farms, so for a livestock farmer who grazed their animals, they may need to adopt the soil and crop nutrition techniques to ensure a good growth of grass.

Another similar option of using all the above techniques as necessary is climate-smart farming which is defined by the Food and Agriculture Organization of the United Nations (FAO) as agriculture which is resilient, mitigates GHGs, increases productivity sustainably and enhances a country's food security (FAO 2010a).

2.3 Agroecology and Sustainable Farming (AaSF)

2.3.1 What is AaSF?

Agroecology is a holistic solution to the impact of climate change and agriculture on each other. The term originated as the application of ecological principles to experimental agricultural work (Bensin 1928). Since then, various interpretations and definitions have emerged, most of which agree that agroecology considers the interrelationships between farming, the environment, society and economy (Francis et al. 2003), whilst studying and applying ecological and socio-economic perspectives and principles to the design and organisation of sustainable agroecosystems (Wibbelmann et al. 2013, Wezel and Soldat 2009). In addition, agroecology considers the whole of the food chain from farm to fork, policies to planting (Agroecology Research Group 2014a). More than a set of scientific methods and agricultural practices, it includes social movements in Latin America as well as the food sovereignty movement (Fitzpatrick 2015, Pimbert 2015), and is estimated to be applied by in excess of 1.4 billion people around the globe (UNEP 2012, Willer et al. 2015). Dalgaard et al. (2003) suggest that there is both 'hard agroecology' and 'soft agroecology', with the former relating to the economy and natural sciences with the researcher coming from an engineering or economy background (Dalgaard et al. 2003). They refer to soft agroecology as that which considers humans and society and their impact with agroecosystems (Dalgaard et al. 2003). This thesis assumes hard and soft agroecology simply under the term agroecology. Tittonell (2014) suggests that, unlike this thesis, agroecology, organic agriculture, and permaculture practices are part of ecological intensification (Tittonell 2014), although Bommarco et al. (2013) use the same terminology for replacing inputs which would release GHG and enhance the productivity of crops through managing the ecosystems on a farm (Bommarco et al. 2013).

Sustainable farming, which is discussed further below, could be described as part of agroecology, including practices such as organic, permaculture, biodynamic or holistic management (Pretty 1995a). However, it does not seem generally to contain the political, non-governmental elements of social movements that agroecology contains (Holt-Giménez and Altieri 2016), so on a continuum from current conventional unsustainable farming practices to agroecology, sustainable farming would appear close to agroecology, but not quite as far along the spectrum as agroecology. It must be acknowledged that Lampkin et al. (2015) suggest a continuum that is not so much of different interventions, such as organic or permaculture (which for this thesis are part of the AaSF practices) as shown in Figure 2-1, but instead it is the adoption and uptake of agroecological techniques and practices, with a conversion of the whole farm system at the furthest end (Lampkin et al. 2015). Tittonell (2014) also suggests a progress from current systems to agroecological landscapes and food systems, but he suggests that it moves thorough different transition zones from optimisation of the current farming practices, to substituting inputs for ones more sustainable, to redesigning the entire farm system (Tittonell 2014). Figure 2-1 below, which was developed through the research of agroecological literature and discussions with members of the Centre of Agroecology, Water and Resilience (CAWR) shows the continuum which has been developed to understand how the different elements of AaSF interact in this thesis. The explanation of transitioning can be found in 2.3.3, whilst unsustainable farming practices as shown at the far right in Figure 2-1 below, are classed as those conventional practices and techniques (Wezel et al. 2015), which deplete natural resources and produce pollution and waste (Pimbert 2015), and as a result, leave fewer resources for the forthcoming generations (Pretty 2008).

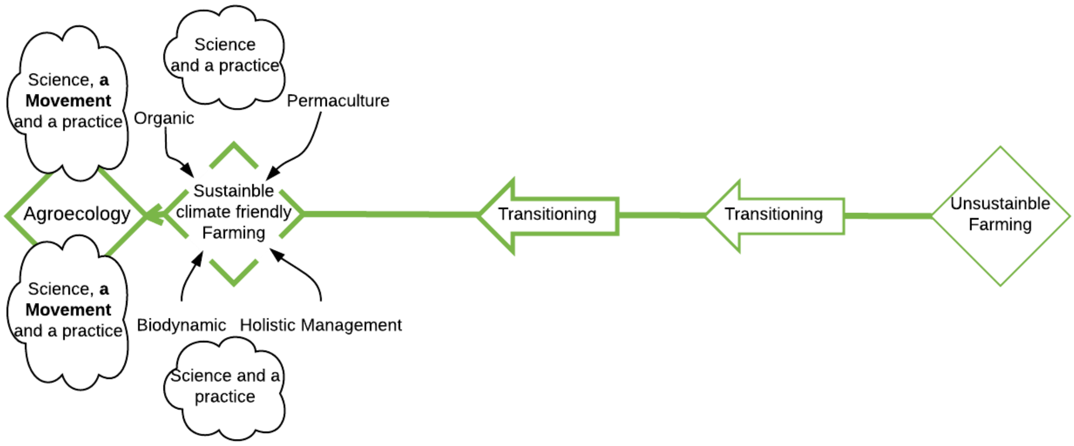

Figure 2-1 Agroecology and Sustainable Farming continuum

For the sake of this thesis, agroecological and sustainable farming practices are explored, and whilst acknowledging the link to social movements, this is not directly investigated.

Whilst the majority of farmers are not yet farming agroecologically, there are a number who are transitioning towards it (Pretty 1995a), either by farming using sustainable techniques which reduce the negative impact on their land, or by taking part in projects which are helping them transition towards farming more holistically (Wezel et al. 2015).

The practice of agroecology attempts to avoid any negative impact on the environment and improve a farm's biodiversity and natural resources such as water and soil. This could be by reducing GHGs through the locking of carbon into the soil (FAO 2015d). It could also be by avoiding harm to waterways, biodiversity, and considering the health of consumers as well (Lampkin et al. 2015). The APPG in Agroecology in their Soil Enquiry of 2015-16 found 'a lack of political will, regulatory structure and advisory services to encourage soil-positive farming – a combination of which could achieve a great deal in the long-term safeguarding of soil' (2016: 3), which could suggest similar hindrances in promoting other agroecological methods which can sequester carbon.

Altieri (1995), one of the major proponents of agroecology, wrote that a key factor in achieving agroecology is restoring the agricultural and biological diversity which can help strengthen the agricultural ecosystem. In addition, by using recycled nutrients or locally bought biological resources and adding organic matter such as green manure (Altieri 1995) rather than external or synthetic resources, soil structure and health which have degraded through intensive industrial farming (Pretty and Hine 2001), are instead rehabilitated (FAO 2015d).

Agroecology and sustainable farming have the potential to strengthen the resilience (Tittonell 2013) and improve the livelihoods of farmers and their families into the future. Gliessman, another renowned author on agroecology, discusses that due to its holistic nature, farmers are encouraged to consider their whole families in their farming as well as their animals, crops and land (Agroecology Research Group 2014b). Livelihoods are also improved due to the strengthening of finances (through diversifying income streams and growing better quality crops from farming using organic, permaculture or holistic management principles (see 2.3.2 below) which can be priced higher than conventional farming); improvement of health (food grown without pesticides and manufactured fertilizers are less harmful to human health (Francis et al. 2003)), and interactions with their peers in similar farmer networks that can help improve mental health as well as social resilience. These improvements can all help to build resilience to future shocks that the environment, government policies, or economy might create (Francis et al. 2003)[30].

As discussed above, agroecology shares many similarities to sustainable farming. The Foresight Committee's definition of sustainability states that 'the principle of sustainability implies the use of resources at rates that do not exceed the capacity of the earth to replace them' (Foresight 2011: 31). Water is consumed only at the rate it can be replenished; soil degradation is halted; pollutants do not contaminate soil,

[30] As can other forms of sustainable agriculture mentioned previously, from climate smart agriculture, to ecological intensification.

water or air; and fisheries, livestock and renewable resources are not used beyond the ability to recover. Adapting from *Our Common Future* (Brundtland and Members of the World Commission on Environment and Development 1987), sustainability refers to a sustainable environment, economy and society, everything that goes into maintaining a sustainable world such as food production, or a healthy economy need to support the population and provide for future generations.

> 'Sustainability also entails resilience, such that the food system, including its human and organisational components, is robust to transitory shocks and stresses. In the short to medium term non-renewable inputs will continue to be used, but to achieve sustainability the profits from their use should be invested in the development of renewable resources' (Foresight 2011: 31).

Sustainable farming, in the same manner as agroecology is more than just mitigating against climate change, although it does often incorporate many 'climate-resilient' farming techniques for mitigating and adapting to climate change (Kremen et al. 2012)[31]. However, sustainable agriculture minimises the impact on the environment; not just reducing GHGs, but also avoiding harm to water ways, biodiversity, and considering the health of consumers as well as the general land (Pretty 1998). It also strengthens self-reliance, and improves the livelihoods, of the farmers and their descendants. Sustainable agriculture can be organic, permaculture, ecoagriculture, or even agriculture using technology, which improves productivity, yet reduces harm to the environment (Pretty 2008). It is a process of learning and change, rather than a fixed model which looks the same on every farm (Pretty 1995b). There is also the discussion of whether one technique (such as using a pesticide) which could improve a farmer's yield, yet harms the environment (all be it less than another technique such as deep tilling the soil) is acceptable. Some conventional farmers may also claim to farm sustainably and this is discussed more in the research data, Chapters 6-7.

As shown in Figure 2-1 above, different associations of sustainable farming fit under the heading of AaSF, including organic, permaculture, and holistic management, each

[31] climate-resilient farming is introduced in Chapter 1.1.3 and defined in the list of definitions.

of which is discussed below (Silici 2014). It is worth pointing out that many of the ecological principles which each movement employs, are similar if not the same, including focusing on improving soil structure and health, and by improving the land and soil, locking more carbon into the ground. As mentioned at the beginning of this section (2.3.1) agroecology goes one step further to include a political edge and movement which most of the sustainable agricultural techniques listed below do not consider.

2.3.2 What are the common farming techniques for AaSF?

Beyond the methods mentioned in 2.2.4 for adaptation and mitigation techniques to reduce GHG that are all relevant AaSF, there are other practices which are also important for farming sustainably and agroecologically[32]. These can include moving away from industrial farming and monocultures to polycultures and 'water harvesting and soil management through increased soil cover' (Third World Network Staff 2015). Other techniques are explained below with the more general ones in Table 2-3 below.

[32] are not just agroecological, and are also used by conventional farmers as 'best practices', but for the sake of this thesis are set within the AaSF section of this chapter.

Table 2-3 AaSF general techniques

Techniques	Description
Pest and disease control	Integrated pest management (IPM), which is an approach to managing pests by combining biological, cultural, and physical such as crop rotation and building biodiversity of pollinators and natural predators (Hine and Pretty 2008), 'in a way that minimises economic, health and environmental risks' (Chel and Kaushik 2011: 92). 'A diverse agricultural system that enhances on-farm wildlife for pest control contributes to wider stocks of biodiversity' (Pretty 2008: 452).
Water conservation	Water conservation is also important, such as storing water or harvesting water during the winter months for irrigation use during the dryer summer months. Pollock states: 'It takes some 10 tonnes of water to produce a tonne of plant material, and water stress significantly reduces solar energy capture and thus yield. The importance of adequate water availability increases as mean air temperatures increase because of increased rates of transpiration' (2011: 23). In parts of the UK, rather than needing to conserve water, there is more likely to be the opposite impact of flooding instead (such as in the west of the country); sustainable agriculture thus needs to adapt to the land, soil and weather conditions, and not apply one rule for every field or farm.
Soil fertility	All the techniques to sequester carbon into the ground (mentioned in 2.2.4), also improve the soil quality, reducing the degradation of UK and global soils which have occurred over decades of intensive farming (Lampkin et al. 2015, Pretty and Hine 2001). They allow deep rooting plants to increase the soil organic matter which lowers water run-off and increases water retention (Shepherd 2015) and increases the soil biota in the form of microbes (bacteria and fungi) which further enables the health of the soil to improve (Gobin et al. 2011).

Animal and plant genetic resource management	Animals are integrated with crops, or mob grazed, which is when farmers split their fields up into small paddocks using electric fences to separate the paddocks and then move the animals everyone to two days[33]. They then do not return the animals back to the first paddock until the grass has grown sufficiently (Chapman 2012). When exploring academic literature regarding mob grazing and rotational grazing, the first searches bring up articles written in the 1990's or mainly for the organic sector (Leach et al. 2014). However, as the topic is further studied, articles written more recently can be found, mainly focused internationally, although a few look more specifically at European if not UK scenarios (Pecetti et al. 2009, Russell et al. 2013, Adegoke et al. 2016, Walter et al. 2013). Beyond academic journals, mob grazing is discussed by the journalistic sector (Morris 2016, Gray 2013, Price 2015, Claxton 2015) and by Nuffield Scholars. These included investigating mob grazing (Chapman 2012), exploring an overview of sustainable grazing techniques (Thornhill 2014), and studying how soil improvement can be improved by no-till, but also through mob grazing as part of crop rotations (Sewell 2014) . This then improves the quality of the grass leys, the soil below the grass, and the health of the animals themselves (Chapman 2012).

[33] This could be considered an intensive adaptation of grazing management, or rotational or paddock grazing and is discussed through the data collection results and evaluation in Chapters 5-7.

Organic agriculture

Organic farming is one of the longest running modern sustainable farming methods around the globe, emerging in opposition to the growth of industrial agriculture between the two World Wars (Vogt 2007). It promotes the use of systems that sustain soil health, animals, people and the general ecosystem, and encourages social fairness (Milestad and Darnhofer 2003). Organic farming reduces antibiotic use in the animals, as antibiotics are only applied when necessary rather than before infections, which can help prevent antibiotic resistance. It also avoids the use of pesticides and herbicides that are not from natural sources (which can harm the land), and instead encourages natural ecological practices and cycles along with promoting local biodiversity (Scialabba and Müller-Lindenlauf 2010). These can include the use of 'predatory invertebrates to help control pests' or only using farm manure during warm seasons when it will decompose quickly and is less likely to wash into the waterways (The Organic Research Centre 2011). There is also a focus on combining and using science, tradition, and innovation to 'benefit the shared environment' and on promoting a wholesome quality of life, and fair interactions with everyone involved (International Federation of Organic Agriculture Movements (IFOAM) 2015).

Farming using permaculture

Permaculture (or permanent agriculture) was first coined as a term by Bill Mollison and David Holmgren in the 1970's as an "integrated, evolving system of perennial or self-perpetuating plant and animal species useful to man" (Holmgren Design 2016). Permaculture explores the ecological systems; the way everything links in nature, and then consciously designs systems which mimic those patterns and relationships. Interested people attend a ten day training course where they learn about permaculture, including the three ethical maxims (earth care, people care and fair share) and twelve principles, and how to apply it to their farm or land (Permaculture Association 2011). Lampkin et al. (2015) include it in their examples of sustainable intensification and agroecology suggests it encourages sustainable living (Lampkin et al. 2015), encouraging farmers to think about the generations to come and can include practices of organic farming, eco agriculture, low carbon and other methods of sustainable agriculture (Pretty 2006, Niggli 2015), whilst rainwater harvesting, recycling, self-sufficiency, restoring and assessing the land to work with it, are key components. In addition, many of the permaculture principles correspond directly with agroecological principles and could play a key part in agriculture transitioning towards agroecology (Ferguson and Lovell 2014). It also is linked to Regenerative Agriculture with the use of Keyline Planning[34] amongst other techniques (RegenAG UK 2014a, Ferguson and Lovell 2014). Many practitioners of regenerative agriculture are also permaculture practitioners (Hosking et al. 2015).

> 'Permanence is not about everything staying the same. It's about stability, about deepening soils and cleaner water, thriving communities in self-reliant regions, bio diverse agriculture and social justice, peace and abundance'(Permaculture Association 2011).

Farming using holistic management

Like permaculture above Holistic Management is one of the many methods that make up Regenerative Agriculture's package of agroecological techniques (RegenAG UK 2014b) and which also utilises Keyline planning. Originally designed for savannahs and grasslands by Allan Savory in the 1960's (Savory 2015), it has become useful for any farmer who wishes to improve the quality of their land, and work with nature to benefit the whole farm from livestock and water, to people and financial planning (Holistic Management International 2015). It is 'a decision-making framework which results in ecologically regenerative, economically viable and socially sound management of the world's grasslands' (The Savory Institute 2015). A side benefit of holistic management is that through improving the land and soil, more carbon is locked into the ground.

Gliessman uses many of the same principles as Holistic Management such as 'managing the whole system' including households (Agroecology Research Group

[34] Keyline uses specific ploughs or subsoilers to plough along the contours of the land, improving water retention, reducing compaction and potentially building top soil (Smaje and Rowlatt 2011, APPG on Agroecology 2016).

2014b), and whilst holistic management and agroecology seem to have evolved in different spheres of agriculture, it could be argued that holistic management, like organic and permaculture, is just another method of farming agroecologically (all be it, without the political movement elements).

It must be noted that permaculture and holistic management remain isolated from mainstream agriculture and is not considered in DEFRA’s annual review of UK agriculture (DEFRA et al. 2014)

2.3.3 Transitioning to AaSF

Gliessman (1997) discusses that when converting to a sustainable agroecosystem, most farmers go through three different stages, rather than rapidly converting from conventional to agroecology. These stages can occur quickly or more slowly over several years. The first stage requires farmers to reduce the use of external chemical inputs on their farm, whilst increasing the economic and environmental efficiency of their current systems. Farmers entering the second level begin to replace the conventional technique, with those techniques that are more agroecologically focused, such as minimum tillage. Finally, the last level requires the farmers to redesign their farm so it functions with agroecological processes (Gliessman 1997). Pretty (1998) also uses three similar steps (with a step zero for conventional farming), but the last step is more community and socioeconomically focused, with attitudes and values of a community becoming more sustainable (Pretty 1998). A brief definition of transitioning is in the definitions at the beginning of this thesis.

The organic movement has had conversion programmes for many years, with certification and standards since the 1970’s (Geier 2007, Soil Association 2017) and policy support beginning to appear among EU states since the 1980’s (Padel and Lampkin 2007). Research on motivations of farmers to convert included environmental and health (animal and human health) concerns (Padel 2001, Rigby et al. 2001, Cranfield et al. 2010), although Darnhofer and Schneeberger in their research of

Austrian organic farming point out that different farmer values, preferences and goals can indicate different rationales for converting (2005).

For farmers to begin to transition, in an ideal world, various structures and processes need to be put in place. On national and international levels, policies may need to be changed to favour agroecological methods of farming (Meek 2016). This may require governments to become convinced of the benefits of agroecology and create the intention of their departments and civil servants to change legislation, or farmer incentives, both at the farm level and throughout the food system[35]. It may also require infrastructure and public perception changes in countries that lack rural infrastructure to enable farmers to sell their agroecological goods. Furthermore, farmer extension networks and agents may need to be encouraged to raise awareness and also to support farmers as they transition (Parmentier 2014). In France, the government has tried since 2013 to 'favour agroecology' in their national budget, and their national strategies, however Levidow comments that NGO's feel that the government's proposals do not go far enough, only encouraging minimum agroecological techniques, whilst community supported agricultural projects also feel that it plays secondary to industrial agriculture with 'imported chemical inputs' (Levidow 2015).

2.3.4 AaSF creating resilience to climate change and other environmental impacts

Through changing to more agroecological and sustainable farming techniques, a farmer can be resilient to climate change (see definition at beginning of the thesis) and other environmental impacts using mitigating or adapting techniques as discussed in 2.2.4 above.

[35] This could refer back to the APPG on Agroecology's work where they have encouraged government policies, regulations and organisations to begin to promote agroecological practices (Pike 2008).

Smith (2009) defines resilience as 'a measure of the capacity to absorb and recover from the impact of a hazardous event.' (Smith 2009: 15), whilst the Oxford English Dictionary (2010) define it as: 'The action or an act of rebounding or springing back; rebound, recoil…. The quality or fact of being able to recover quickly or easily from, or resist being affected by, a misfortune, shock, illness, etc.; robustness; adaptability' (Oxford English Dictionary 2010). The United Nations Office for Disaster Risk Reduction (UNISDR) expand Smith's definition to state that resilience is 'The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management' (UNISDR 2017). Darnhofer (2014) suggests that when considering the resilience of farms there needs to be an understanding that the farm needs to not only 'bounce back' after a shock, but have the ability to 'bounce forward', to persist against a hazard, adapt to it and gain the capability to transform or mitigate so to avoid that hazard in future (Darnhofer 2014: 466–467). For the sake of this thesis, the definition of resilience is an amalgamation of the above, and merely states: *resilience is understood as the ability (of a person, farm, community) to withstand, cope, adapt to, recover from, transform and mitigate against future shocks, stresses, hazards that may occur*.

Pretty argues that sustainable agriculture can help build a farmer's capital assets such as natural, social and human assets (Pretty 2008: 452) which could then help build a farmer's resilience and thus strengthen their livelihood. Using the livelihoods framework Figure 2-2 below (which will be discussed in more detail in the Chapter 3), it shows that assets help vulnerable households stay resilient to natural disasters, shocks or drastic changes. Equally, with agroecology and sustainable agriculture, UK farmers can build those assets and therefore strengthen their resilience to withstand financial, environmental, or psychological pressures (Siedenburg et al. 2009: 2).

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure 2-2 Household Urban Livelihoods Framework. From unpublished MA dissertation (Hartless 2008: 9) **adapted from** (Sanderson 1999: 3)

One example of this, is the pressures farmers experienced with flooding, first in the South-West of England during the winter of 2013-14 (Muchan et al. 2015) and then to the north of the country in the winter of 2015-16 (Marsh et al. 2016), as discussed in 2.2.3. Through support networks (Roomi and Redman 2016), alongside financial aid from the government (Priestley 2016), many farmers were resilient enough to recover from losing livestock or crops due to flooding on their land (Dale-Harris 2017, Farming UK News 2016).

2.4 Exploring behaviour change on UK farms in relation to building climate-resilient farming communities and livelihoods

As discussed above, it is important to encourage agroecological and sustainable farming to mitigate and adapt to climatic impacts, building a farmer's resilience to those impacts and thus improving their livelihoods. Exploring how to change a farmer's behaviour to more agroecological farming techniques is fundamental as farmers are diverse, and different influences can promote change for one farmer and discourage change in another farmer. Policy and regulations (which can be voluntary) can insist on change, but without the wholehearted support of a farmer, any changes may just be superficial and may not increase resilience or strengthen that farmer's livelihood. As a result, when exploring and promoting sustainable agricultural behavioural change for farmers, there must first be an understanding of the different drivers and barriers to agroecological change, as well as different behavioural change theories and models, which exist to promote change. Even then, the change process will probably be slow. Pretty (1995b: 1249) argues that 'Sustainable agriculture is, therefore, not simply an imposed model or package. It must become a process for learning and perpetual novelty'.

2.4.1 Generic barriers and constraints to promoting sustainable agriculture behavioural change

To promote sustainable agricultural behavioural change, there must also be an understanding of the obvious opportunities, drivers, barriers, disincentives and incentives for a farmer to become sustainable. These opportunities and constraints can also influence farmer's livelihood, improving or hindering the ability of the farmer to improve their assets and access resources. It is also important to understand the best approaches or activities to promote change, and understanding of that change, amongst the farming population (i.e. the different ways to adapt and mitigate for climatic impacts). Pike states that 'understanding and influencing behaviours is an inter-disciplinary challenge' (Pike 2008: 21).

In the process of transitioning to AaSF, there are several barriers and constraints that a farmer might experience. DEFRA commissioned a report to assess the attitudes of farmers and their likelihood of adopting mitigating methods to reduce their GHG emissions and become more sustainable (Barnes et al. 2010). The report identified five barriers to farmers changing their behaviour. Those were structural, financial, educational, management, and administration.

In addition to the five barriers above, an additional one of behaviour and social aspects has been included. This is due to the fact that whilst DEFRA does not include these aspects, four other articles refer (as barriers and constraints) to behaviour or social aspects (Dwyer et al. 2007, Rodriguez et al. 2009, Altieri and Nicholls 2005, Silici 2014).

Table 2-4 on the next page draws from nine research articles regarding barriers and constraints to farmers changing their behaviour, in order to identify subcategories of these barriers and constraints to farming agroecologically. Each barrier is coloured to show the category it falls into in relation to the DEFRA report and the behaviour/social aspect category as shown below.

Structural	Financial	Educational	Management	Administration	Behaviour / Social Aspects

Table 2-4: Showing barriers and constraints to farming agroecologically in the nine research articles listed above.

Structural [1]	Financial [1, 3, 7]	Educational [1]	Management [1, 7]	Administration [1]	Capacity to change [3]
Tenure constraints [3] Insecure land tenure [4] Tenure of land [8]	Practical barriers [2]	Information barriers [2] Spread of information / access to / lack of [8]	Lack of Time [3, 7, 8]	Policies benefiting conventional [4]	Willingness to change [3,] Willingness to change / resistance to change[8]
Subsidies and incentives for conventional [4]	Finance - incentives and subsidies for agrochemicals [5]	Conceptual barriers [2]	Requiring too much labour [3,4]	Government polices, programmes and subsides [5, 7]	Social skills to work with other farmers [4]
Lack of access to natural resources [4]	Finance - lack of [5]	Knowledge [4, 5, 8] education / information / complex systems [8] Lack knowledge or skill [7]	Management skills [4]	Marketing and pressure from advisors and agrochemical companies [5]	Social and health issues [5]
Wholesale markets for products* [6]	Lack of Subsidies [6]	Perception of it being too complex [4]	Large-scale mechanised agriculture (reduction in farm labour, and land seizures) [6]		Farmer characteristics [8]
Processing set up for industrial farming (structural) [6]	Value added* [6]	Lack of Experience [5]	Biofuel instead of food* [6]		Beliefs / myths [8]
Poor infrastructure [6, 8]	Different equipment required [7]	Lacking Communication [5]	Biofuel focus so less likely to rotate crops away from corn*[6]		Social factors [8]
Government subsidies [7, 8]	Economic limits - costs to change / increase in labour [8]	Myths - small scale only [9]	Resources [8]		Social and cultural acceptance amongst peers [8]
Physical conditions of land [8]		Myths - subsistence orientated, not compatible with markets [9]			
		Myths - opposed to science and innovation [9]			

The superscript numbers correspond to [1](Barnes et al. 2010), [2](Fleming and Vanclay 2010), [3](Dwyer et al. 2007), [4](Silici 2014), [5](Altieri and Nicholls 2005), [6](Magdoff 2007), [7](Drost et al. 1996), [8](Rodriguez et al. 2009), [9](Castillo 2014). Where there is a * the barrier is specific to the USA (although this may change).

As noted above on page 40, in 2010, DEFRA commissioned a report which included five barriers to farmers changing their behaviour. The structural issues involved conflict with other government policies, age, tenure agreements of farms and complexity. The financial ones were mainly the impression of the costs of adapting and mitigating. The educational issues link to the Farming Futures report discussed below, where farmers feel there is nothing they can do, not knowing and understanding about GHGs and ways to mitigate. The management issues were all related to the day-to-day running of their farms, from costs of fertilisers, the size of the farm and the weather. The administration issues were around complexity of policies, negative language and possibility of regulation (Barnes et al. 2010: 20–25).

Despite this, a number of farmers in the UK have already started farming using sustainable and agroecological techniques as described in 2.3.2 above, and from an economic point of view, others have adopted certain elements such as using minimum tillage to reduce their time and fuel spent ploughing a field (Lawson and Bullock 2007). This will be investigated further in the data collection.

2.4.2 Farmer training, learning, networking and extension; drivers and enablers

Agricultural extension was traditionally seen as involving ‘the conscious use of communication of information to help people form sound opinions and make good decisions’ (Ban and Hawkins 1988: 9). However, it has evolved over the years to include facilitating learning (Burton et al. 2006), building empowerment (Davis and Sulaiman V 2016) and supporting farmers to obtain information and solve problems (Anderson 2007). In this latter understanding, training then becomes a tool in which to apply agricultural extension. This can be formal with external extension workers, or informal with farmers leading the extension and problem solving.

Pollock emphasises the need to build training and extension into any sustainable agricultural policies to help producers understand the need for changing their farming practices to become more sustainable (Pollock 2011). As his case study was part of the supporting documentation for the Foresight Committee's report on *The Future of Food and Farming*, it is understandable that one of their priorities for action; spreading best practice, included giving skills training, and providing incentives to food producers 'to meet current and future challenges' (Foresight 2011: 34).

Garforth states that those food producers' sources of education, training and advice have traditionally come from five directions. The first is informal communication such as between peers and colleagues. The second are 'individual innovators who feel they have something useful to share'. The third are non-governmental organisations from the NFU to scientists, universities and more recently organisations via the Internet. The fourth are commercial enterprises such as fertiliser sales people, vets or consultants, and lastly, the fifth is the government (which in the UK is mainly through the agency of DEFRA and the devolved government departments for agriculture[36]) (Garforth 2011: 3).

With modern technology, farmers can share knowledge and solve problems through social media, or SMS messages. There are Twitter feeds such as #*agrichatUK* or #*teamdairy* that farmers can use to share experiences (Twitter 2016). AgrichatUK also host a twitter farming discussion forum for farmers and other interested people to ask questions on a certain topic every Thursday night between 8-10pm, or share experiences (AgriChatUK 2014a). However, it is worth pointing out that fibre-optic broadband is still being rolled out to many rural areas including parts of the Welsh Borders, and Herefordshire. As those locations are also unlikely to have strong (if any) mobile communication networks or mobile Internet, farmers working in the more remote parts of the UK are still restricted in their communications and therefore their avenues of learning (Davies-James 2016).

[36] See footnote 8 on page 5 for the list.

In an example of both informal and formal extension as mentioned above, Mills et al. looked at collective community sustainable agricultural behaviour in two farming communities in Wales, explaining that larger-scale sustainable agricultural projects were more beneficial and successful than the odd individual farm (Mills et al. 2011). Neither group had direct funding from governmental agri-environmental schemes, but did benefit from grants from the Welsh Development Agency, Wales Council for Voluntary Action and Countryside Council for Wales. In addition the research was part funded by the Welsh Assembly Government (Mills et al. 2011). Mills et al.'s analysis revealed that despite the differences between the two studies (one only had ten farmers, whilst the other had 100 with a committee); both groups appreciated the social and learning aspects of the collective and had begun to farm more sustainably as a group. The groups worked best having decided common objectives and aims. This may still have worked if the groups did not know each other before the collective formed, but that they were neighbours helped the cohesiveness of the groups.

Similar to Garforth, there were external influences such as facilitators who supported the co-operatives, helping the members develop their skills. The members stated that 'the best facilitators... were those people who were local, respected by farmers and able to enter into dialogue with them' (Mills et al. 2011). However, rather than transferring knowledge of what to do, the facilitators encouraged social learning enabling 'farmers to find their own solutions' to problems (Mills et al. 2011: 77). Mills et al. also discovered that it was important to adapt the agri-environmental schemes (AES) to the local people and their situations to take into account the relevant motivations, which could vary from financial to protecting rare breeds. The authors mention that within the UK, existing funding for setting up AES is complex, and without careful thought, could hinder or harm the potential of a collective from forming a successful AES. However, 'The research also showed that ultimately, investment in cooperative agri-environment schemes can lead to more confident farmers with a greater cultural embeddedness of environmental practices' (Mills et al. 2011).

Pike also highlights the benefits of cooperatives and collective action. He states ‘co-operation between farmers is nothing new, working together has been a feature of agrarian life for centuries, and whilst (voluntary) farmer cooperatives may be less prevalent in the UK compared to other EU member states, a set of economic and environmental circumstances may provide a catalyst for farmers and landowners to begin to work together again’ (2008: 16). Farmers can be competitive, but can also work together. However, the key is to discover the best way to stimulate interdependent people into coming together, following pressure from the environment, to create strong, effective groups (Pike 2008). By cooperating and creating community consensus, groups can share learning, bringing environmental and sustainable changes whilst reducing risk (for instance, sharing machinery, or building cooperative wind farms) (Mills et al. 2011).

2.4.3 Exploring behaviour change of farmers

In a comprehensive report on behaviour change models for the UK Government, Darnton examined and categorised over 40 theories and models (2008). Key ideas which are drawn out of the models include internal and external influences on behaviour; intentions leading to behaviour change, and self-efficacy, or one’s belief that that one can successfully do something, and by completing it, it can help in the overall outcome (Darnton 2008). This helps with understanding why farmers may change their behaviour or not, as changing a farmer’s behaviour towards agroecology may be harder if there is a lack of self-efficacy. This is explored further during the data collection, where there may or may not be a lack of self-efficacy or intention. This is discussed further in Chapters 5-7 and this data may provide opportunities in the future to build the resilience of the farmers through increasing their self-efficacy and intention. This section only includes a number of studies and reviews, there are many more which have not been included as they were seen as less relevant to this thesis.

Emery and Franks note that if a farmer perceives that their neighbours are unlikely to be interested or positive about collaborative agri-environmental schemes, it would provide barriers to the farmer joining or even discussing the scheme if it differs from the general farming community's cultural norm (2012). Mills et al. found that cultural barriers also played a part, as farmers were concerned that their neighbouring farmers might feel they had a reduced crop if agri-environmental management schemes were implemented in their fields (Mills et al. 2013).

Fishbein and Ajzen introduce norms as part of their Theory of Reasoned Action (TRA)[37] and their revised Theory of Planned Behaviour (TPB)[38]. Norms relate to the influence of others on one's behaviour - whether they think one should or should not behave in a particular way. Such beliefs, along with the motivation that they can cause together can be labelled the 'subjective norm' (Fishbein and Ajzen 1975)[39].

Other ideas discussed include habit (repeated behaviour becomes unconscious and automatic and potentially leading to routine), emotions swaying behaviour, and that of norms (Darnton 2008, Government Communication Network and Central Office of Information 2009). Norms can be 'descriptive' or 'injunctive'. The former are social norms or cultural norms – 'the group 'rules' that determine what is deemed 'acceptable' behaviour. Social norms can have a huge influence on our thoughts and behaviours' (Government Communication Network and Central Office of Information 2009). The latter are the laws and regulations of society, such as speed limits, or the smoking ban[40].

[37] The Theory of Reasoned Action (TRA) was originally created by Fishbein and Ajzen to understand attitudes and behaviour, and the influences both externally or internally upon that behaviour (2008). Darnton explains that it assumes that between attitude and behavioural outcomes are intentions and that those intentions lead to behaviour (Ozmete and Hira 2011: 389)

[38] The Theory of Planned Behaviour (TPB) 'adds to the theory of reasoned action the concept of perceived control [self-efficacy] over the opportunities, resources, and skills necessary to perform a behavior' (Government Communication Network and Central Office of Information 2009: 23).

[39] As discussed in Chapter 2, Norms can be 'descriptive' or 'injunctive'. The former are social norms – 'the group 'rules' that determine what is deemed 'acceptable' behaviour. Social norms can have a huge influence on our thoughts and behaviours' (2002). The latter are the laws and regulations of society, such as speed limits, or the smoking ban.

[40] Other behaviour change models which were of less relevance to the thesis are discussed in Appendix 1.

As Darnhofer et al. state:

> 'farmers' choices are constrained by their personality, preferences and competences, but also by external structures such as social norms, technologies and the natural environment. Acknowledging that there are different valid solutions for each problem allows one to see that a farmer might find some solutions more useful than others depending, e.g. on her priorities, farming style and context' (Darnhofer et al. 2010: 549).

Dwyer et al.'s analysis of data for their behaviour change report to DEFRA suggests one method which might suit Darnhofer's analysis would be 'one-to-one farm visits' and that 'advisors need to have very good knowledge of farming and preferably the systems found most often on the farms with which they will be dealing' (Dwyer et al. 2007: 36, 49). They also discuss willingness to change which has relevance to the data (see chapters 5-7).

Pike explains that the planned behaviour and reasoned action theories are 'the most relevant for thinking about policy and the underlying psychological issues' (Pike 2008: 5). TRA or TPB could be applied to agricultural behaviour change, as the theories would enable exploration of the famers' attitudes to sustainable agriculture and climate change, the social norms of their peers, and their self-efficacy, so that they could implement the changes required for sustainable agriculture successfully. Burton states 'Within agriculture, where farmers are subject to fluctuations in the physical, economic and political environments, perceived behavioural control can play an important role' (Burton 2004: 366).

Both Pike and Dwyer et al. note that change takes time and can be uncertain, particularly to embed in farming cultures, and instead of 'simply changing attitudes, new social structures and new beliefs about 'good farming practice' need to have time to develop' (Dwyer et al. 2007: 47). There is also be the problem that some farmers either may not fit the general direction of any initiatives promoted and therefore miss out on the targeted information, whilst others may simply do not want to change, or the disincentives might be too strong e.g. economic (Dwyer et al. 2007).

Behaviours can be very complex and there is diversity amongst farming industry, so no one analysis is suitable for all. One individual may approach a specific behaviour one way, whilst another may use a different way. Therefore, it is important to evaluate behaviour at all stages and note that responses to behavioural change will vary from group to group (Pike 2008). Pike also notes that information does not always create awareness and awareness does not always change behaviour. Equally, attitude change does not necessarily change behaviour. Hence, there is a need to understand all the factors affecting behaviour and use a multidisciplinary model for change (internal, external and social). Working within the different farming cultures and alongside groups within each culture can help to change behaviour (Dwyer et al. 2007). As can 'securing lasting change, in an effective way, requires shifts in attitudes, norms and habits as well as addressing external factors through policy interventions' (Pike 2008: 11).

Exploring behaviour change research on farmers can provide knowledge which will benefit the data collection for this thesis as it can help assess what motivates those who change. For example, do they have greater self-efficacy, or have some agroecological farming techniques become a social norm for farmers belonging to a certain organisation? This was investigated via questions in the data collection to farmers regarding why they may or may not use a technique. It can also help in the evaluation of the data, applying learning on behaviour change to analyse the results of discussions with farmers.

2.5 Overview of existing agroecological interventions in the UK

It was important to look both at interventions which are already working with farmers to encourage and help them change their farming practices, to mitigate and adapt to climate change, as well as at those interventions which promote agroecological techniques as a proxy for climate-resilient farming.

2.5.1 Government interventions

Government policies, farming schemes and the Common Agricultural Policy (CAP)[41]

There are several long running as well as some relatively new projects across the UK to encourage farmers to farm more sustainably. Some of the former include Government projects such as DEFRA's and the corresponding devolved administrations agri-environment schemes, which incorporate over half the farmland across the UK. Since the beginning of 2015, they have been funded by the EU Common Agricultural Policy (CAP), which makes payments to the United Kingdom and now includes agri-environmental foci, 'with 30% of direct payments linked to three environmentally-friendly farming practices: crop diversification, maintaining permanent grassland and conserving 5% of areas of ecological interest' (European Commission 2014a: 1).
In England, this includes 'Basic Payment and Rural Development Programme for England' (DEFRA 2015b).

Prior to the revision of CAP, the main English agri-environment scheme was The Environmental Stewardship scheme that provided funding for farmers who practice land management which benefits the environment (DEFRA et al. 2014). This scheme has now come to a close, and any farmers wishing to apply for funding now need to apply for either the basic payment or countryside stewardship (DEFRA 2015c).

Scotland, Wales and Northern Ireland now have the same schemes as England funded by the CAP – Basic Payment and the Rural Development Programme, although they may choose to develop different schemes under the CAP funding. This includes Wales' principle agri-environmental scheme Glastir which is funded by the Rural Development Programme and Welsh Government, which will continue to run for the foreseeable future (Welsh Government 2016a). Scotland and Northern Ireland's agri-environmental schemes opened at the beginning of 2017 and contain measures to

[41] this was written in the Spring 2016 before the UK voted to leave the EU. As a result, over the next few years, CAP funding and other EU funding and regulations for the UK agriculture sector may change drastically.

improve the environment of the UK's farmed land including support for organic, regenerating woodland and reducing GHG emissions (Scottish Government 2017, DAERA 2017).

DEFRA, Welsh, Scottish and Northern Ireland research

These are not strictly interventions, but indicate where government has had interests. DEFRA has funded research on a variety of topics related to climate change and agriculture. A brief look at their science and research projects website set up in 2003 reveals over 9000 projects, many of which relate to multiple conventional and sustainable agricultural practices from animal health, to GHG emissions with research spanning back to the 1990's (DEFRA 2003)[42]. Furthermore, of the projects that directly fit in their 'agriculture and climate change' theme, there are 192 projects (DEFRA 2015d). As a result, criteria were developed to narrow down which DEFRA projects to investigate further. The research criterion looked for projects within the last ten years which explored practical activities relating to the topics of climate change, agriculture, adaptation or mitigation, (within which there is a vast selection of topics including GHG mitigation, knowledge transfer and behaviour change), which farmers can implement, or the afore mentioned organisations can use, to create sustainable farming interventions. In addition, for the sake of this review, only those projects which have final reports on the DEFRA research portal have been considered. Of these, seven projects fitted the criteria and are summarised below.

Three of the projects looked at mitigating against GHGs, from the feasibility of GHG mitigation methods (ADAS UK Ltd. 2010a), to specifically reducing GHG emissions from nitrogen fertilisers (ADAS UK Ltd. 2010b), to practical action to reduce GHG emissions (Institute of Grassland and Environment Research 2007). The first two projects also look at barriers to change, with a feasibility report finding that depending on which mitigation methods were used, the main barriers were to do with knowledge and

[42] The search engine on this website reference continues to search for new projects despite a date of 2003 at the bottom of the webpage, and so includes current DEFRA projects as well.

understanding of GHGs, including lacking the knowledge of the consequence of N_2O, and how it relates to fertiliser (ADAS UK Ltd. 2010a). Research into reducing GHG's related to nitrogen fertilisers found that in addition to the expected time and cost barriers, weather was one of the biggest barriers, with a lack of confidence in the forecasts predicting a rain free period in which to apply the fertilisers (ADAS UK Ltd. 2010b). A report on practical action discovered that it was important to carry out future field-based research for mitigation methods such as minimum tillage (Institute of Grassland and Environment Research 2007).

The remaining four projects research a variety of topics related to climate change and agriculture. These included reducing fossil fuel inputs which revealed that the horticulture sector using glasshouses had the 'greatest potential for energy saving' (Warwick HRI and FEC Services Ltd. 2007: 46), as well as exploring English agri-environmental schemes and the importance of protecting biodiversity 'in the face of climate change' (Warwick - HRI 2007: 20). Topics also researched included the impact of climate change on UK crops, and adapting them to higher temperatures and an increase in CO_2 or 'changing planting dates or crop locations' (Warwick HRI 2009: 17), and exploration of the likelihood of farmers changing their agricultural management methods to adapt to extreme climatic events. The latter showed that very few UK farmers have made management plans for any changes in the climate between now and 2020 and therefore 'intervention will be needed if wide scale adoption of some mitigation adaptation is to be achieved in order to meet Government and social expectations with regards to the environment and land management' (ADAS UK Ltd. 2008).

The Scottish Rural College is linked with the Scottish Government's climate change policies to commit 'to a reduction of 80% in Greenhouse gas emissions by 2050' (Scottish Government 2010). *Farming for a Better Climate* run by Scotland's Rural College (SRUC) includes research, practical guides to improve farm profitability and soil, together with ways farms can adapt to climate change (SAC Consulting 2015a).

The project also includes climate focus farms which provide the opportunity for farmers to meet and discuss ways to become more resilient to climate change by improving their farm profitability and reducing their carbon footprint (SAC Consulting 2015b). The college further hosts a Future Farming Systems Group, which explores issues which farming may face in the future and how they can adapt to meet those challenges. Solutions are explored scientifically and tested in-situ. They include smarter livestock farming and carbon management (SAC Consulting 2015c).

Whilst the other two devolved government bodies do undertake research for their countries on a variety of topics including agriculture and the environment, they are not as extensive as England or Scotland. The Welsh Government is encouraging farmers to farm sustainably (Welsh Government 2014), and in terms of research, they are mainly focused on collecting the data for the *Agriculture in the United Kingdom* reports (DEFRA 2016), and investigation into the incidences of tuberculosis in cattle (Welsh Government 2016b). However, they also have funded research for the Land Use Climate Change Group (LUCCG). The LUCCG report recommended that agriculture is productive, but also reduces the intensity of the average emissions through 'adopting best practice in herd health and nutrition and ensuring a high proportion of output meets market requirements', improving emissions from fertilisers, increasing woodland, and encouraging renewable energy (ADAS UK Ltd. 2014: 43).

In Northern Ireland, the majority of their research is run by the Agri-food and Biosciences Institute (AFBI), although they also have research linking with the United States (DAERA 2016a). Of the AFBI research programmes, money has been allocated to research projects including researching the ability of farming in Northern Ireland to cope with climate change; researching improving soil health and managing soil nutrients; and reducing GHG from manure and slurry (DAERA 2016b).

2.5.2 Non-governmental interventions and organisations

Whilst the interventions and movements below all stand apart, there are links between each, with similar practices, methods, and values. As permaculture was discussed as a technique in 2.3.2, it is not discussed here as an organisation or intervention. However, it must be acknowledged that as the Permaculture Association, it is also an organisation with international connections through their bi-annual international conference (International Permaculture Convergence 2017). GHGAP and industry road maps were discussed in Chapter 1, so they are also not included in this section.

Soil Association Innovative Farming Projects and Future Farming Programme with Duchy Organics

Although the Soil Association are an organic organisation, they have also been running programmes for farmers from both organic and conventional systems under their Innovative Farming Projects (Soil Association 2016). These projects have included the Low Carbon Farming (LCF) project (Soil Association 2013a) and the Duchy Future Farming Programme (DOFF) (Soil Association 2014a) amongst other research. The projects aim to focus on research (on-farm), exchanging knowledge or experience and work with researchers to improve organic and non-organic farming for future challenges (such as environmental, waste or diet). Whilst the Low Carbon Farming project has now finished, the website contained useful resources for a couple of years after completion, including a carbon calculator, LCF handbook, case studies and fact sheets, videos and an infographic. An evaluation report on the 'business benefits of low carbon farming' was produced in 2013 for the Soil Association by members of the Organic Research Centre (Gerrard 2014), and was turned into an infographic showing different low carbon practices and how effective they are at reducing carbon and providing financial benefits (Adams 2013). Since 2016, the website no longer contains all the knowledge gained over the course of the project including the tools mentioned above, which were distributed widely. Case studies on the site suggest that the project was successful, with farmers using their carbon calculator to assess their farm and adapt their farming practices for low carbon farming. However, specific impacts such as quantitative data or qualitative data from farms using the techniques are not currently on the website to show further impact.

Since 2012, Duchy Organics and the Soil Association have been running their Future Farming Programme (DOFF) (Soil Association 2014a), although over time the focus has moved towards Innovative Farming and specifically field labs (Soil Association 2015). The programme is aimed at organic and non-organic farmers and growers, but there is an emphasis on low-input farming (Soil Association 2013b).

Taking concepts from participatory learning, farmers around the country are encouraged to run farm labs on a topic of interest to the host and the attending farmers and growers, exploring on-farm practices that examine innovative or new techniques to tackle farming problems related to improving and increasing productivity whilst adapting to environmental impacts. The lab trials are run over a year, with up to four meetings with the same attendees, with successes and failures of the lab reported as they go along (MacMillan and Benton 2014). Due to the choice of topics, the labs successfully interest conventional farmers as well as those already transitioning to agroecological farming, and as a result, are a valuable method of positively promoting agroecology to those who are unaware of it.

Regenerative Agriculture UK (RegenAG)

Regenerative Agriculture UK has been running courses, consultancies and innovative training on a variety of agroecological topics including organic, permaculture and holistic management since 2011. They offer farmers, growers and other interested parties a variety of techniques, which can help to regenerate farming by improve soil fertility, build soil, and benefit the environment, along with farming communities and financial profits (RegenAG UK 2015). These techniques can also mitigate against GHGs as they can increase the amount of carbon locked into the soil (Lal 2004b), and reduce usage of petroleum inputs by offering alternatives such as bio fertiliser, or minimising use of machinery (RegenAG UK 2015).

RegenAG UK remains unique in its ability to reach the wider farming sector, encouraging sustainable change whilst still focusing on food production and income generation. It also is adaptable to different climates, with holistic management originating in savannah lands, but now being used successfully in the United Kingdom.

Many farmers have gone on to make changes, and some are engaged in sharing knowledge they learnt with their peers (Hosking et al. 2015). Whilst Regenerative Agriculture mainly runs introductory workshops, they have also started running master-classes, where farmers share what they have implemented and seek advice about areas where they are struggling, with peer-to-peer training. This is discussed further in Chapters 6 and 7.

Agriculture carbon calculators and FCCT interventions

There are a number of carbon calculators and GHG calculators, and Whittaker et al. (2013) and Smith and Little (2013) both review a good number of them. However, this review assesses briefly six calculators, which meet the following criteria. They must be in the public domain, free to use and designed for farm management; to encourage farmers and growers to assess the GHG emissions for individual factors or a combination of factors on their farms including crops, fuel, electricity and livestock. Farmers can then adapt their management and farming techniques to reduce their emissions.

It could be argued that Carbon Accounting for Land Managers or CALM (Country Land & Business Association 2015a) is aimed more at those who own land rather than tenant farmers by default of the organisation itself (Country Land & Business Association 2015b). However, it could also be suggested that a tenant farmer does manage their land and hence is a land manager and the tool would be of benefit. The calculator is easy to use, providing you have the data ready to input (Smith and Little 2013). It not only measures GHG emissions from livestock, soil, crops and fuel, but also considers of the Environmental Stewardship agri-environmental schemes and can help farmers assess their current emissions and also 'what if' scenarios to assess if changes will benefit their farms (Country Land & Business Association 2015a).

The Cool Farm Tool enables growers and farmers (and at the other end of the supply chain, companies) to make decisions for their farm to reduce their environmental impact (Cool Farm Alliance 2014). This tool was the most useful in Whittaker et al.'s review, scoring higher than the other reviewed tools for transparency, informativeness and comprehensiveness (2013). Farmers using the tool have the opportunity to assess their carbon footprint and by making small management adjustments, assess what would contribute most to reducing GHGs. This tool probably has the widest reach to suppliers and farmers across the globe as it was developed with Unilever; multinational companies have used it amongst their suppliers (Smith and Little 2013).

CPLAN was set up by two farmers in Scotland who wanted to understand their GHG emissions and after creating the calculator, made it available to other farmers (Coulter and Coulter 2015a). It has two versions, the first a basic version, which does not save the results, but is free to use, and the second a more complex version that has a fee per calculation, but does save the data (Coulter and Coulter 2015b). Whittaker et al. only assessed the free version and it scored the lowest of all of the tools mentioned here in their multi-criteria-analysis (2013). However Smith and Little point out that the second version is linked to a paid consultancy that the site also offers, and reports from the second version are more detailed and concise than the basic version (2013). Colomb et al. also suggest that the paid tool is relatively easy to use and is not time consuming (2013).

Managing Energy and Carbon tool is a pdf file, which can be downloaded and printed, to complete on paper for those with no or low computer skills. However, because it is on paper, it is more awkward than the previously mentioned tools and does not include any calculations for carbon sequestration (Smith and Little 2013). Nevertheless, it does include energy saving sheets, which suggest alternative ways to reduce energy consumption and costs (ADAS Wales 2015). Like CPLAN above, this was not evaluated by Whittaker et al. and is merely mentioned as an option for advice and information in Lewis et al. (2013) and Tzilivakis et al. (2014).

Farm Carbon Calculator (FCC) and Farm Carbon Cutting Toolkit (FCCT) states that

> 'The aim of FCCT is to encourage and support farmers and growers to reduce their farm greenhouse gas emissions, increase their farm energy resilience and in doing so also improve their farm business in the future' (FCCT 2014a).

Like CPLAN this was also set up by farmers and consists of a carbon calculator, but also a guide written by farmers on the wider context of impact of GHGs such as climate change, specific farm GHGs and how to take action (FCCT 2014b). This was the only tool to score higher than the Cool Farm Tool for user friendliness on Whittaker et al.'s review (2013). It has been argued that FCC is aimed at organic farmers only (Smith and Little 2013, Tzilivakis et al. 2014, Whittaker et al. 2013). However, on perusal of both the calculator website and toolkit website, whilst there is still a slant towards organic farmers, there are also options to complete for non-organic fertilisers, and animal feeds, so other non-organic farmers can also now complete the calculator (Smith 2014).

Food & Farming Futures, and Agricology (online interventions)

Set up in 2006 as a collaboration of various organisations including the National Farmers Union and Forum for the Future (Frazer 2007), Food & Farming Futures is a resources website which was created for farmers to help understand and prepare for any impacts that the changing climate could create. The website also provided ways that farmers could create opportunities from any impacts, and create 'profitable business in a changing climate' (Farming Futures 2017). Between 2008-11, they surveyed farmers' opinions on climate change. In 2008, of the 408 farmers interviewed (with equal quotas per region and farm type) 60.3% felt that they were already experiencing climate change impacts on their farms (Associa Research 2008), whereas in 2011 of the 400 interviewed, only 34% felt they were experiencing impacts (Farming Futures 2011). No explanation of the drop in this figure has been offered, and surveys since 2011 have been run by DEFRA as part of the data collected for the Agricultural Statistics and Climate Change reports. From 2011 they were taken over by a joint partnership including The Institute of Biological, Environmental and Rural Sciences (IBERS) and have continued to provide useful resources to farmers including an on-going blog, events page and newsletter (Farming Futures 2017).

Agricology was set up in late 2015 to share research and knowledge to farmers (Agricology and Smith 2015) as well as profiling farmers who are innovating and using agroecological techniques (Agricology 2015). Featuring research, blogs, fact sheets, computer and smartphone applications and videos, practical knowledge is shared in an accessible format for all who are interested (Agricology 2016). Many of the agroecological techniques and interventions are introduced in detail and then discussed further on their blog. For example at the beginning of 2017 a report of a RegenAG workshop on holistic management was shared along with links to relevant resources from the site (Clegg 2017). The site also contributes to social media, including that they helped to host an AgriChat farming discussion on soils on the 16th February 2017 (AgriChatUK 2017).

Other interventions and organisations were researched prior to the Phase 1 data collection, but the direction of the research evolved over the time of the thesis and some organisations no longer exist in their current format. As a result, they were moved to the end of Appendix 1.

2.6 Diagrammatic version of the theoretical framework.

Drawing from the theories in this chapter, a visual diagram was developed to help explain the theoretical framework.

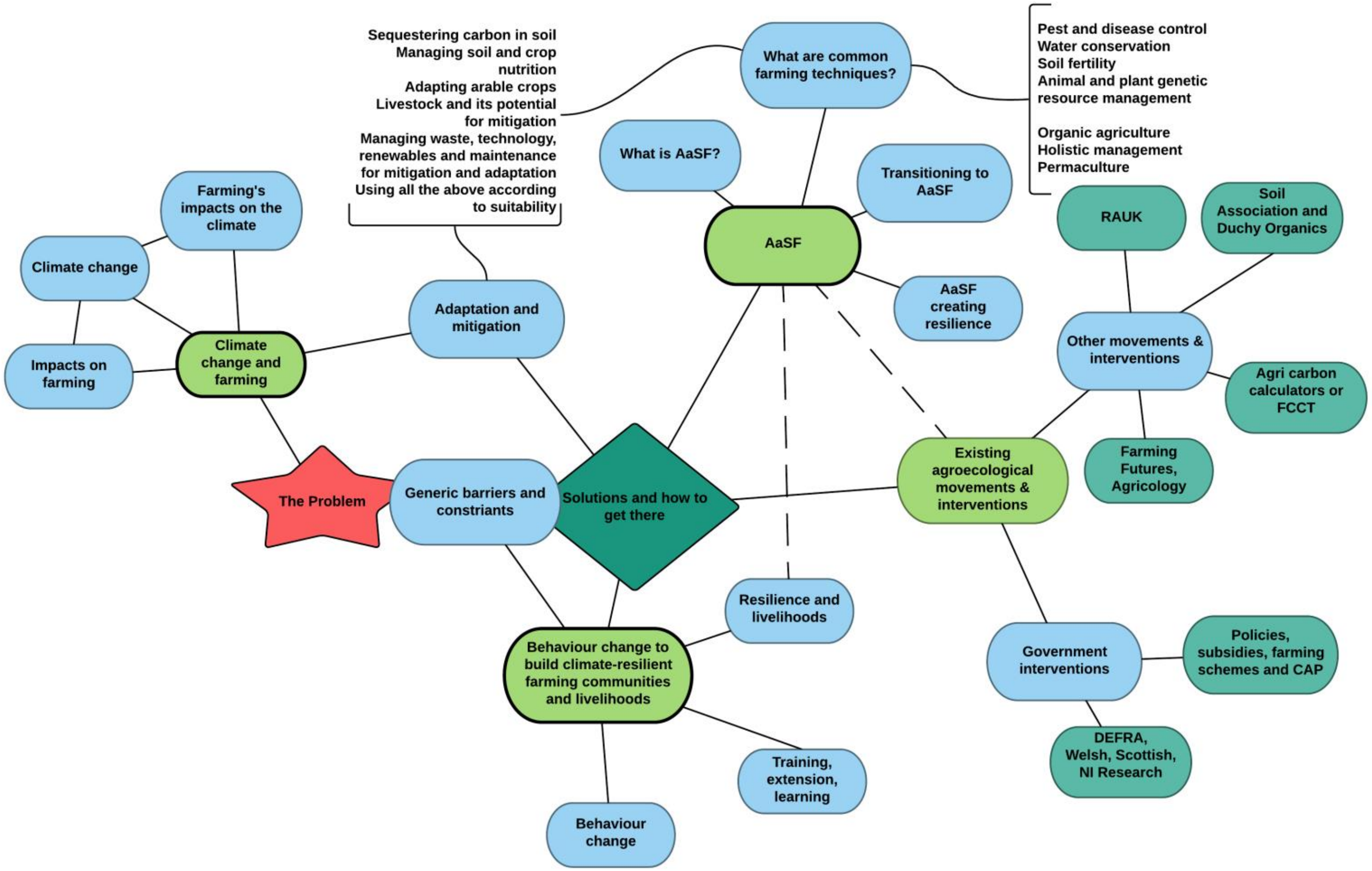

Figure 2-3 Diagram of the Theoretical Framework

2.7 Summary

This chapter has covers a wide field of topics that help to narrow down and formulate theories to expand the justification in Chapter 1 and to consider responses to the question 'assuming climate change will impact on a farmer's livelihood, what would make a farmer change their behaviour to farm in a climate-resilient manner using agroecological techniques?'

The chapter first looked at literature around the problem of climate change and its relationship to farming, both positive and negative. This was then expanded to study what agriculture could do to mitigate or adapt to a changing climate, looking specifically at climate-resilient farming methods that could mitigate against GHG emissions, or adapt to changing temperatures, or weather patterns.

In Section 2.3, the chapter then explored agroecology and sustainable farming, the meanings behind those theories and the common farming methods for those concepts and how they are distinct from mitigation methods, yet still relate to climate-resilient farming practices. The section concluded with a discussion about ways that a farm could transition to agroecological and sustainable farming. The chapter then discussed reasons that agroecological farming in the UK is not happening to a larger degree and focuses on farmer behaviour. Section 2.4 explored different facets to behaviour change, from increasing farmer resilience to climate change by strengthening their livelihoods (discussed more in the Chapter 3), to barriers and constraints hindering change. This section then looked at learning and farmer extension, along with behaviour change of farmers in the UK, which can help to establish the best methods or language to use when engaging with a certain group of farmers to encourage them to begin to farm agroecologically. The section concludes with a brief summary of the theories behind behaviour change such as the self-efficacy of farmers, and their habits.

Finally, in Section 2.5, the chapter turned towards exploring environmental interventions that are already taking place in the UK, firstly looking at government policies and subsidies that encourage environmental initiatives in farmers, and then specific movements of AaSF from organic, to permaculture, from holistic management, to regenerative agriculture.

The next chapter develops a analytical framework by exploring in detail livelihoods and climate-resilient farming, with a discussion of the Sustainable Livelihoods Frameworks and how assets can help build farmer resilience to shocks and stresses from climate change. The rationalisation for the approach to researching this topic is critically explored in Chapter 4.

Chapter 3 - Conceptualising sustainable livelihoods for climate-resilient farming to develop an analytical framework for the research

3.1 Introduction

Building on themes found in the previous chapter, this chapter develops concepts of sustainable livelihoods and creates an analytical framework to further the research. In doing so, it describes why and how the framework is adapted from existing livelihood frameworks to be appropriate for the UK context. The adapted analytical framework is shown below (Figure 3-1). Whilst the chosen sustainable livelihoods frameworks are used in this chapter as a way to understand and analyse vulnerabilities of UK farmers, their resilience to climate change and environmental impacts, and ensuring they have sustainable livelihoods, they are not all incorporated into Figure 3-1. Instead, as discussed below, select concepts are used from the other frameworks to help understand each individual element of the adapted framework (Figure 3-1).

The discussion first explores the sustainable livelihoods approach (SLA) and how it relates to agroecology, climate change, climate-resilient farming,[43] and to the UK context. It then examines at four frameworks; the common Department for International Development's (DfID) Sustainable Livelihood Framework (SLF) (DfID 1999), two adapted from the SLF to consider agroecology specifically, and the Household Urban Livelihoods Framework (HULF), developed by CARE International and introduced in this thesis in Chapter 2 (Hussein 2002)[44]. The DfID SLF is well established. The agroecological frameworks have significance with respect to UK agroecology, whilst this chapter argues that the HULF is relevant to the UK, and that it is appropriate for it to be adapted as an analytical framework for this research.

[43] As discussed previously, climate-resilient farming is defined as farming in the UK which can be resilient to, (that is withstand, adapt to, recover from and mitigate against) any impacts of climate change.
[44] Other frameworks can be found in Hussein's thorough report (IDS 2017).

The chapter then explores in more detail the different facets of the HULF framework, beginning first with the shocks and stresses that can impact a livelihood, then the household, assets and access to resources and barriers.

The chapter ends by looking at how the analytical framework below (Figure 3-1) has been adapted to a UK rural agricultural context.

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Figure 3-1 UK Rural Livelihoods Framework adapted from the HULF for this research

3.2 Sustainable livelihoods and agroecology

3.2.1 What are sustainable livelihoods?

Chambers and Conway, whilst they were working at the Institute for Development Studies (IDS), defined sustainable rural livelihoods (SRL) as comprising:

> 'the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation…' (1992: 6)

They go on to discuss how the livelihood of an individual should also contribute to others and their livelihoods locally, globally, and over differing time periods (Chambers and Conway 1992).

Later work emanating from the IDS adapted the definition slightly, describing assets as 'both material and social resources', whilst also stating that the livelihood needs to not undermine 'the natural resource base' (Scoones 1998: 5). This could be defined as all the natural elements available such as the soil, water, minerals, flora and fauna that can be found in any particular location, although for livelihoods this tends to relate to those elements found in common access waters or lands (Robinson 2016). Scoones also created the livelihoods checklist diagram which he states was the basis of the DfID framework described in 3.3.1 (Scoones 1998: 4, 2009).

With both definitions, there are tangible assets (stores and resources; material resources) and intangible assets (claims and access, social resources) and both types of assets (tangible and intangible) are required to build the asset base. Whilst assets are discussed further in Section 3.3; as briefly mentioned in Chapter 2, Section 2.3.4, the building of a farmer's assets can help strengthen their livelihood if their resilience to shocks and stresses are increased.

Furthermore, when exploring livelihoods in the context of sustainability, a definition needs to incorporate what Robertson calls the three E's of sustainability – economics, equity and environment (2014: 5). Thus a sustainable livelihood needs to avoid harming the environment, and contribute to building social equity and the economy, much in the same way as Brundtland's three pillars of sustainable development – environment, society and economy (Brundtland and Members of the World Commission on Environment and Development 1987). This also applies to climate change, and a sustainable livelihood needs to avoid activities which harm the environment (and through that, impact the climate) (Scialabba and Müller-Lindenlauf 2010). Equally, though strengthening livelihoods, and through adaptation and mitigation techniques, people are more resilient to climate induced shocks and stresses (Mulvany et al. 2015). Applied to farming, as a farmer or farming community strengthens their livelihood(s) and through agricultural adaptation and mitigation techniques, the farmer or farm community will become more climate-resilient.

When looking more closely at agriculture, sustainable livelihoods and climate-resilient farming may be seen as linked, as through utilising climate-resilient farming techniques, a farmer implementing those changes can improve his or her assets, resist shocks from climate change and strengthen his or her livelihood (Silici 2014, FAO 2010a). Equally, through improving a farmer's livelihood and his or her assets, it would increase resilience to shocks and stresses such as climate change (Pretty 2003). This is woven into the sections below.

3.2.2 How do sustainable livelihoods interact with agroecology and sustainable agriculture?

Chamber and Conway's livelihood definitions relate to the poor[45] and includes farmers and those in rural areas (1992). For farmers, tangible assets suggested include farm

[45] The IDS define chronic poverty as anyone who has remained for over five years under the poverty line (Office for National Statistics 2016), this definition relates to global poverty. The UK definition is defined 'as experiencing relative low income in the current year, as well as at least 2 out of the 3 preceding years.' And relative low income is defined as 'an individual living on an equivalised [sic] disposable income of less than 60% of the national median.' (Chambers 1995, 2009).

equipment or livestock, whilst soil degradation or declining yields are used to describe shocks and stresses (Chambers and Conway 1992).

Moreover, whilst sustainable livelihoods concepts have long been linked to sustainable agriculture (Chambers and Ghildyal 1985, Pretty and Hine 2001), when the sustainable livelihood definitions are applied to the latest interpretation - agroecology, they are very similar to Gliessman's ecological definition of sustainable agriculture that states:

> 'A whole-systems approach to food, feed, and fiber production that balances environmental soundness, social equity, and economic viability among all sectors of the public, including international and intergenerational peoples. Inherent in this definition is the idea that sustainability must be extended not only globally but indefinitely in time, and to all living organisms including humans.' (Gliessman 2014)

In 2011, the *Journal of Sustainable Agriculture* focused on integrating sustainable livelihoods with agroecology to improve rural development, and how it could occur in reality (Gliessman 2011). More than once in that journal, authors explore the correlations between sustainable livelihoods and agroecology (Amekawa 2011, Addinsall et al. 2015). Amekawa comments that sustainable livelihoods and agroecology share important similarities and could further learn from each other (2011) whilst Addinsall et al. agree, commenting that 'Combining agroecological and sustainable livelihoods approaches enables interdisciplinary research that incorporates principles from sociology, economics, agronomy and ecology' (2015: 691). Both articles go on to discuss the topic in more detail, which is discussed below in Section 3.3.

3.3 The appropriateness of using sustainable livelihoods concepts in the context of more industrialised regions

This section first looks at how sustainable livelihoods can be applied to people in industrialised countries including generally in the UK, before looking specifically at sustainable livelihoods in the context of the UK agricultural sector.

3.3.1 Can sustainable livelihoods be used in industrialised countries?

Sustainable livelihoods frameworks have been used predominately in less industrialised regions, where poor people may experience shocks and stresses, and need resilience to overcome them. This does not assume that all people in less industrialised regions are poor, and acknowledges that even some farmers in those same regions might be wealthy. However, Chambers points out that rich people[46] may hinder the livelihood improvement of poor people in any part of the world, by exploiting resources, degrading the land, or creating barriers to access (such as accessing government, funding, resources, markets and fair prices for goods) (Chambers 1986).

In Chambers and Conway's paper *Sustainable Rural Livelihoods: Practical Concepts for the 21st Century*, the authors were farsighted in their descriptions of an increased population in the next century (our current century), which we now know numbers far more than at the time of writing the paper in 1991 (UN DESA Population Division 2015). In this paper, in an effort to ensure sustainable rural livelihoods for the poor in the future, they acknowledged that if the rich use up resources there would be none left for the poor. The authors thus indicate that policies need to encourage lower demands on the natural resource base by the richer countries, so future rural generations can maintain sustainable livelihoods (Chambers and Conway 1992).

Furthermore, Chambers more recently stated that 'the least environmentally sustainable livelihoods and lives are 'ours': those of the better-off and relatively richer people' (Chambers 2009: 1). He goes on to discuss the concept of 'net sustainable livelihoods effects', that existing livelihoods can harm or enhance 'other livelihoods and their sustainability'. Chambers also indicates that international or global

[46] Chambers defines the 'rich' as those of us living in industrialised countries, including himself and others reading his papers, or watching television (2016). The World Bank count the UK as a 'high income country' (World Bank 2016) which does not reflect UK poverty as discussed in the previous page's footnote. However, for the sake of this Section 3.3, with the rich or more industrialised regions exploiting resources (which could include wealthy farmers), the World Bank category applies, along with all other countries within that category (Farm Business Survey and DEFRA 2017).

dimensions may impact on net livelihoods effects such as international trade agreements or free trade (as opposed to fair trade) or subsidies for agriculture in richer countries (Chambers 2009: 1). Chamber's article refers to livelihoods on an individual level, not considering how it might apply to rural communities in more industrialised regions. This suggests that maybe Chamber's work is less relevant to more industrialised countries like the UK. However, other authors and organisations (as discussed below) have applied the SLA to rural and urban industrialised communities. This includes DfID (1999), and it must be acknowledged that Chambers does considers communities alongside livelihoods with regards to his Participatory Rural Appraisal (PRA) work (Chambers 1994a, 1995, 2007). Furthermore, in Chamber's 1995 article, his explanation of livelihoods includes gaining an income from multiple activities which could correlate with farmers from more industrialised countries diversifying to gain their living (Chambers 1995).

Other authors and organisations have also started applying sustainable livelihoods to more industrialised regions. Bowen and De Master discuss rural livelihoods in relation to European countries and how the global agro-food system and quality standards can undermine the livelihoods of the local, traditional farmers such as dairy farmers in Corsica (2011: 78). Kneafsey et al. in their report to the European Union, look at short food supply chains, local food systems and the importance of both in contributing to sustainable livelihoods (2013).

In addition, Oxfam GB have started applying a SLA to their UK poverty programmes, such as in areas of Wales (Oxfam Cymru 2013). This is a part of their belief that everyone has the right to a sustainable livelihood (Hocking 2003), and they have found that even in a more industrialised country like the UK, there are significant numbers of poor or deprived people whose livelihoods are not sustainable (Orr and Brown 2006). Oxfam believes that 'by looking at the day to day experiences of people's lives…. the assumption that in order to make ends meet people draw upon a combination of different assets that are available to them' (May et al. 2009: 9).

3.3.2 Sustainable livelihoods in the UK agricultural context

Whilst Oxfam have used the SLA to assess and help poor communities in the UK, they have also used the approach to assess farm livelihoods in rural areas of the UK and determine the best approaches to making those farmers resilient to shocks and stresses (Ponder and Hindley 2009). An example of agricultural financial stresses would be the loss of income for those farmers who did not lose their livestock during the foot and mouth crisis in 2001, yet were unable to sell their animals due to restrictions, creating financial stresses for those farmers (Scott et al. 2004, Franks et al. 2003).

When looking at the UK agricultural sector, despite farmers in the UK having significantly more income than a farmer in a less industrialised regions, where livelihood frameworks were originally designed (Chambers 1986), they still need to earn enough to sustain their livelihood. Moreover, *The Economist* reports that living costs in the UK are more expensive than other less industrialised regions of the world (The Data Team 2016). Furthermore, the UK has seen agricultural income in the UK decline (Shucksmith and Herrmann 2002, Glover and Reay 2015, Zayed 2016, DEFRA and National Statistics 2017c), which alongside a variety of stresses such as the foot and mouth crisis in 2001 (Rossides 2002), or the current issues with tuberculosis (TB) in cattle (Brooks-Pollock et al. 2014), could have further reduced the sustainability of some farmers livelihoods[47]. The Farm Business Survey (FBS) records farm incomes annually and since 1995, farm incomes have fluctuated. Total income from farming (calculated by 2015 prices) dropped by 72% between 1995 – 2000 (Zayed 2016). Since then it has been climbing up, but the most recent figures show that it has dropped since 2013 from £5,585 million to £3,610 million in 2016 and had dropped by 7.5% since 2015 (DEFRA and National Statistics 2017c). The FBS also includes information

[47] This applies specifically to farmers who have had cattle that have been affected by foot and mouth, or bovine TB.

about diversification. McNally used the survey between 1988-1997 to produce her article on farm diversification and found that tourist accommodation and renting farm buildings were the greatest recorded diversification activities, whilst farm retail provided the greatest diversified income (McNally 2001). More recently, the results from the 2015-16 FBS suggest that in addition to 'letting buildings for non-farm use' (DEFRA and National Statistics 2016a: 18), renewable energy is the next most popular diversification activity. The report suggests that whilst letting buildings has 41% of the diversified farms, and renewable energy has 23%, when looking at income, letting buildings provided the greatest income of 42% (£410m of £1,000m) however, 42% of their total farm income, farm food processing and retailing generated greater proportionally (£50m of £120m). Looking back at renewable energy, whilst it was popular amongst farmers, it only 'generated 9% of their total income (£60m of £650m)' (DEFRA and National Statistics 2016a: 18). Other indicators of vulnerabilities in the UK agricultural sector include structure change and farm closures. Regarding the former, following the change to subsidies in 2005 shifting away from production, farmers who had previously increased the number of livestock on their farms, had to restructure their businesses (Acs et al. 2010, Zayed 2016). Regarding the latter, between 2005-2016, the number of agricultural holdings in the UK reduced by 29,046 (DEFRA 2017b) whilst the number of dairy producers in England and Wales dropped between September 2007 to September 2017 by 3319 producers (AHDB Dairy 2017). Therefore, it could be argued that sustainable livelihoods are valid when exploring the UK agricultural sector and agroecology in particular.

However, in addition to Ponder and Hindley's study (2009), only two other studies have applied the SLA to agriculture in the UK. Firstly, Maxey et al. look at creating sustainable livelihoods on small agricultural sites '*10 acres or less*' in the UK (Maxey et al. 2011). They explore different case studies where the grower followed a slow development trajectory which allowed him/her to avoid commercial loans, yet at the same time developed complimentary skills such as carpentry, to help keep the costs down, and allow their livelihood to develop in harmony with their smallholding ecosystem (2011: 6). Secondly, Saltmarsh et al. used the SLA to guide their research into community supported agriculture (CSA) schemes in the UK and their various assets, which helped the authors analyse the factors that were affecting the livelihoods of those CSAs (Saltmarsh et al. 2011).

The relevance of sustainable livelihoods to UK farmers will be discussed further in the latter half of Section 3.4 onwards.

3.4 Exploring livelihoods frameworks: the Sustainable Livelihoods Framework (SLF), adaptations of the SLF and the Household Urban Livelihoods Framework (HULF).

This section initially explores DfID's sustainable livelihoods framework (SLF) as a tool frequently used to improve livelihoods (Morse et al. 2009, Hussein 2002). It then examines two frameworks that use the SLF as the basis, but adapt it to work with agroecology, which, reflecting the aim stated in Chapter 1[48], makes it of more relevance to this thesis. The section further critically explores the household urban livelihoods framework (HULF), which was designed to consider urban livelihoods including the needs of a household, along with access and barriers to resources. This chapter then examines in detail adapting the HULF to use as an analytical framework for this research.

3.4.1 DfID's SLF

In 1997, DfID started to promote the concept of sustainable livelihoods in their work with less industrialised countries. A year later, the Department adapted the IDS livelihoods framework checklist (Scoones 2009) to create DfID's Sustainable Livelihoods Framework (SLF), shown in Figure 3-2 below.

[48] The aim states: To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities and livelihoods.

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Figure 3-2 Sustainable livelihoods model adapted from (DfID 1999)

This was then presented at the Department's Natural Resources Advisors' Conference, on the understanding that Chambers and Conway's definition of SRLs (1992) was accepted along with the SLF, to help as a practical tool for practitioners working to develop and support livelihoods (Carney 1998). Since then, it has been used and adapted by organisations around the globe (Hussein 2002).

Table 3-1: Showing the development of sustainable livelihoods in the UK and beyond.

Year	Event	Organisation
1992	Chambers and Conway define Sustainable Rural Livelihoods (SRL)	IDS
1997	The new Labour government create DfID and the department starts to promote sustainable livelihoods	DfID
1998	Scoones adapts the definition slightly and creates the livelihoods checklist diagram	IDS
1998	DfID adapt the IDS checklist to create the Sustainable Livelihoods Framework (SLF)	DfID
1998	Natural Resources Advisors' Conference accept Chambers and Conway's definition and the SLF	DfID
1999	CARE create the Household Urban Livelihoods Framework (HULF)	CARE International
2000 onwards	The SLF, sustainable livelihoods and the HULF are used throughout the world, in different organisations and different sectors.	

Table 3-1 above shows a timeline of the development of sustainable livelihoods.

DfID state that the framework is centred on people, with arrows 'denoting a variety of different types of relationship, all of which are highly dynamic' (DfID 1999: 1).

The vulnerability context

Working from the left to the right of the framework (Figure 3-2), the first influence on a sustainable livelihood is the vulnerability context. This part of the framework is used in the analysis of vulnerability and the impact of hazards which are categorised under three different vulnerability contexts: shocks, trends and seasonality. A person may experience vulnerability from sudden shocks such as health problems, famine, or environmental impacts like a hurricane, or drought (Amekawa 2011, DfID 1999). They may also experience longer-term trends. For instance, this could be that an increasing population could impact negatively on food supplies (Amekawa 2011). Another example is the situation in the UK, that austerity measures after the financial crash in 2008, alongside rising food prices, have caused negative trends for those who are poor, with the associated increase of the number of food banks that have been set up to ameliorate their needs (Loopstra et al. 2015). The last context is the negative impacts from seasonality (or as Amekawa calls it 'stresses' (2011)), that occur every year such as dry seasons, or monsoon seasons. A minor example is that of the UK hayfever season, which occurs annually and contributes to health problems (both minor and major) of everyone who suffers from it (de Quincey et al. 2016). However, the framework appears to not take into account situations where two or three of the elements occur concurrently, discussing only the individual elements with examples such as the ones in the previous couple of sentences. An example of multiple elements occurring concurrently could be with regards to the winter weather in the UK between 2015-16, where the initial storms Abigail (November 2015) and Desmond (December 2015) provided a shock, followed by a series of further storms causing a trend until February 2016 (McCarthy et al. 2016). Furthermore, as these storms were part of a wider decade of wet winters arguably related to climate change (Kendon 2014), they also fit the vulnerability contexts of seasonality or stresses. Thus, climate change can contribute to all three of these influences. As discussed in Section 2.3.4, increasing resilience makes a farmer resilient to hazards, shocks and stresses such as those categorised in the above vulnerability context. This is a topic discussed in a number of academic articles including Berkes (2007), Olesen et al. (2011), Nicholas and Durham (2012) and Griffiths and Evans (2015).

Livelihood assets

The next influence on a sustainable livelihood is a person's assets (or their capital), the more assets a person has, the less vulnerable they will be to any of the shocks, trends or stresses (Amekawa 2011). DfID framework, including the assets, works at the individual scale, the household scale and community scale (DfID 1999), with the person using the framework assessing and deciding at what scale to use the framework (Scoones 1998). The human assets include the knowledge and skills that are inherent in a person, along with their health, all of which enable them to work to gain a sustainable livelihood (Scoones 1998). The natural capital can include the weather, soil, water, air, the natural resource stocks which enable crops to be grown, or livelihoods to be sustained (Scoones 1998). The financial capital is the income a person generates, any savings they have, and any other income they possess or can generate. The physical capital is the basic infrastructure of a country, plus what people need in order to earn an income, so roads, tools and equipment, housing and transport (May et al. 2009). The last asset is the social assets: relationships with family and friends which can support a person, social networks, affiliations and associations which a person could draw on to withstand vulnerable contexts (Scoones 1998).

These five assets are not rigid, other organisations have added or reduced the number of assets they refer to, whilst the assets suitable for a UK farmer are discussed more in Section 3.4.

Transforming structures and processes

'Governance has much to do with the two-way 'influence & access' arrows between a people's assets and transforming structures and processes' (DfID 1999: 18). DfID describe structures as the hardware, and processes as the software, whilst Carney breaks the two down to be structures (governmental, non-governmental and private organisations) and processes (laws, governmental incentives, policies) (Carney 1998).

Both structures and processes can be useful: structures can offer guidance and training, whereas processes can offer a means to / or not to change (i.e. incentives to get renewable energy, or laws limiting use of pesticides[49]). Also, both can influence a person's livelihood informally or formally (Scoones 1998). Culture, such as a caste system is an informal example of how a person can be limited in improving their livelihoods (DfID 1999), whilst the more formal laws and regulations can impact on trends such as the austerity measures mentioned above (May et al. 2009).

Analysing the links between these and the assets can reveal the restrictions or constraints that impact on the livelihood's level of sustainability (Addinsall et al. 2015), or how people can cope and recover from shocks and stresses that they may face (Hussein 2002).

Livelihood strategies

The IDS at the University of Sussex broke down livelihood strategies into three types: 'agricultural intensification/extensification, livelihood diversification and migration' (Scoones 1998: 9) and focused on the idea of structures and processes mediating livelihood strategies (Scoones 2009)[50]. In the UK, whilst to some extent all three types of strategies may apply to farmers, migration is generally away from agriculture, with the children of farmers migrating away from their family farms to gain a different

[49] These could also include policy incentives to mitigate or adapt to climate change.
[50] In this thesis, agroecology could also be considered as a livelihood strategy.

future. For most of the agriculture community in the UK, the more common strategies are diversifying and/or intensification/extensification, adaptation and mitigation strategies such as minimum tillage, alongside making financial changes (tighter budgets, saving more), or using community and social networks for support, which help with building their assets to improve their strategy of sustaining a livelihood (Wilson et al. 2011, Wilson 2014, Scoones 1998). By accessing their assets (the processes and structures that affect those assets, and the vulnerabilities and hazards that a person may face) a person can be influenced to develop or choose different livelihood strategies (Addinsall et al. 2015). Furthermore, in a cyclical manner, the more flexibility and choice a person has in their livelihood strategies, the better they are able to withstand or adapt to any shocks or hazards (DfID 1999). Livelihood strategies can also lead a person to achieve their livelihood outcomes.

Livelihood outcomes

DfID deliberately used the term 'outcomes' rather than 'objectives' to avoid suggesting any government or development agency were pushing specific objectives (1999). They also believe that outcomes would focus on achievements which would promote action (DfID 1999). The outcomes listed in Figure 3-2 are not the only ones, but are categories that help with participatory inquiry to discover which are applicable to the relevant situation. Carney states that practitioners and researchers should learn from the individual or group that they are working with, about their own outcomes and 'their own understanding of what it means to be in and to escape from poverty (as well as their own beliefs about the root causes of that poverty)' (1998: 9). Whilst this concept of participatory people-led work has been used by IDS for many years, including Chambers PRA work amongst farmers (Chambers 1994b, 1994a, 1994c), in the years since Carney's writing, people-led and participatory strategies have become more important in livelihood dialogues (Björklund et al. 2012). These include Addinsall et al.’s work with the agroecological farmers in the South Pacific (Addinsall et al. 2015) and Oxfam’s work in the UK described earlier in Section 3.3.1.

The Sussex IDS also include outcomes which could feed back into the assets, making them stronger, so as to help make a person’s livelihood that much more resilient to the vulnerability context, and therefore more sustainable (Scoones 2009).

Starting in 2002, DfID began to no longer use the SLF in the majority of their programmes, or to promote it within new projects (Clark and Carney 2008), with human rights and governance coming to prominence in dealing with international trade and national development issues which the SLF was felt not to address (Pinder 2009). However, it still is used by many non-governmental organisations (NGOs) who receive DfID funding, whilst other organisations such as Oxfam GB have been using it over the last decade within the UK poverty sector (Oxfam Cymru 2013). Oxfam’s work has broken down the SLF and provided tools and activities for individuals to use to help them identify each part of the diagram. These include the power and influence line, which enables communities to map the policies, local or national government bodies, and service providers that make decisions and set agendas for the local area. They can place those structures and processes along the line to show how much power they have and how easily they are influenced (Oxfam Cymru 2013). These individual tools dissect the SLF to ‘enable the participants to reflect on (and the researcher to document) the strengths of their current livelihoods strategies, and the barriers that they face in improving the situation’ (May et al. 2009: 34).

3.4.2 Adaptations of SLF for agroecological farming

As mentioned above, since DfID’s framework, others have adapted it to suit their programmes (Hussein 2002). Some keep the structure similar, whilst others use vastly different frameworks. However, because the SLF emerged from a development context, most adaptations (beyond those discussed in Section 3.3) relate more to the less industrialised regions. The two frameworks discussed below are relatively recent and are relevant and useful to this research because they were adapted specifically for agroecology. They are discussed below.

Modified framework for agroecology

As mentioned above, Amekawa's 2011 paper looked at the similarities between agroecology and sustainable livelihoods. He discusses the importance, when appropriate common and divergent elements between sustainable livelihoods and agroecology are mixed together, of exploring the 'conceptual and methodological syntheses prepared within an integrated framework' (Amekawa 2011: 121) to provide integrity and coherence to the combination of the two practices (agroecology and sustainable livelihoods).

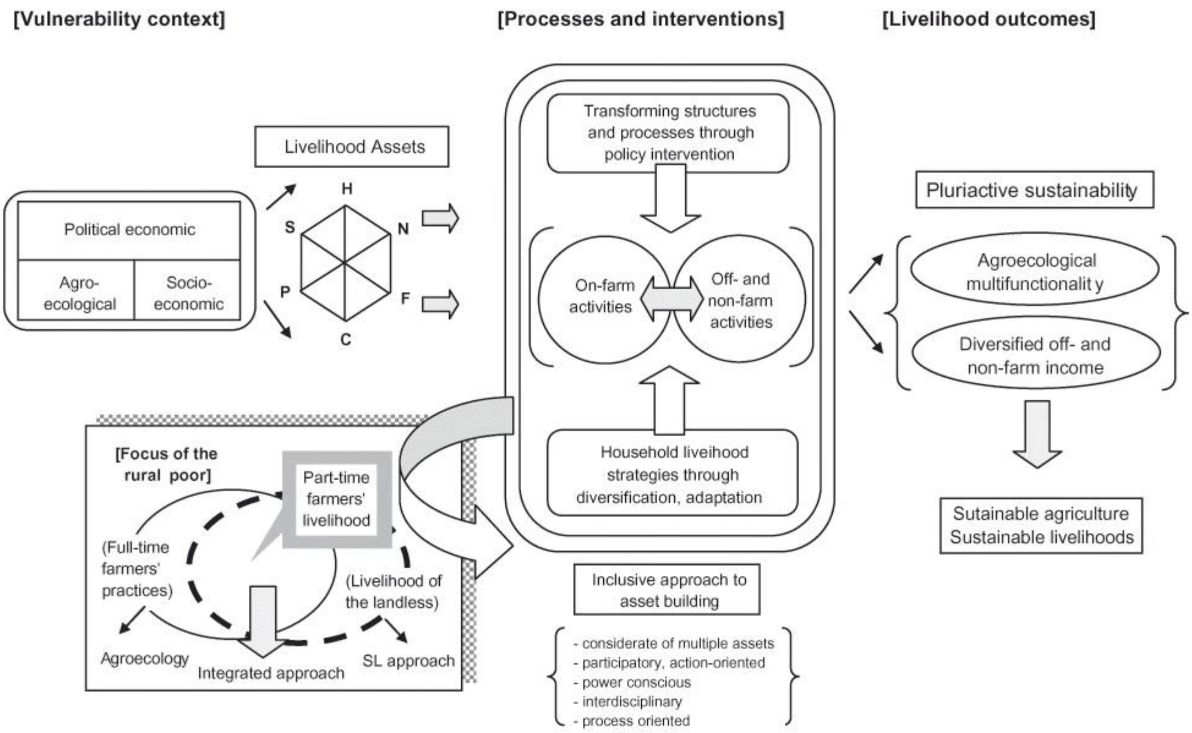

Figure 3-3 Used with permission*[51]* from (Amekawa 2011: 143)

Amekawa adapted the SLF (see Figure 3-3[51]) to show the integrated approach between sustainable livelihoods and agroecology to rural development (2011). He modified the SLF using five different concepts.

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[51] Taylor & Francis is pleased to offer reuses of its content for a thesis or dissertation free of charge contingent on resubmission of permission request if work is published.

His first concept focuses his framework specifically on agroecologically based small farms, and notes that the agroecological small farm is different from the conventional, with more focus on farmer knowledge, low and locally available inputs and conserving resources. Amekawa also acknowledges that many farmers who have small farms are part-time and have other employment (2011). This also has relevance to the UK, as discussed at the end of the discussion on this framework (page 92-93).

Triple vulnerability perspectives

Amekawa has changed the vulnerability context, so rather than looking at shocks, trends and seasonality, the framework incorporates three different perspectives: the political economic, the agroecological and the socioeconomic (2011).

The first perspective is political economic, which Amekawa mainly refers to as political systems (including regimes such as democracy, and administration such as government policies) and economic systems (such as world food prices, population growth and negative impacts of climate change) (2011: 144). The political economic context is spatially larger and longer-term in its vulnerability context than the other two perspectives, considering not just the local area, but also that of a region or country. As listed above, Amekawa also includes climate change under the economic examples of his political economic perspective. However, whilst climate change fits with the category's spatially larger and longer-term description, it is not clear in Amekawa's article (aside from economic impacts of climate change) how other impacts of climate change, such as social impacts fit in this category. The other two categories (agroecological and socioeconomic) are more locally and imminently specific in their context of vulnerability. The socioeconomic perspective relates to access to resources for an individual, community or household, whilst the agroecological looks more specifically at engaging in practices of agroecological farming and the local or regional environment which can impact on that (Amekawa 2011: 145). Whilst each of these three perspectives might contain shocks, stresses, or seasonality (as per the SLF), they do not consider vulnerability perspectives related to culture (which is additional to the ASRLF below). Instead, culture is seen as an asset and is discussed in the next section.

For successful sustainable livelihoods approaches, all three contexts need to relate to each other to address the links between the local and wider global structures (Scoones 2009). Thus, Scoones (2009) and Amekawa (2011) suggest that political ecology (which encompasses political economy with the socioeconomy and agroecology) is a good way to examine those cross dimensional links of the three contexts.

Participatory and inclusive asset building

The third change in Amekawa's adapted framework is a sixth asset that joins the five mentioned in the SLF section above. Amekawa adds cultural capital to acknowledge the importance of individual viewpoints and interpretations, alongside local knowledge, the knowledge and traditions of a community (Economic and Social Development Department 2005, Amekawa 2011). Amekawa also stresses that building any of the assets must be inclusive, using strategies which not only improve a person's financial assets, but at the same time more of all six assets (2011). He explains that assets of small scale farmers are complex, and often contain a tangled web of intangible and tangible assets, both of which should be considered of equal importance (Amekawa 2011). Furthermore, participatory approaches should be used to build assets, as each person should have input in the building of their own assets, as that will help to empower them and increase their resilience. The approach must also recognise the social and power relations, including the interactions between individuals and society, which exist amongst those participating in livelihood programmes, and use sensitivity to ensure that poorest are given a voice, alongside being included and empowered (Scoones 2009, Amekawa 2011). Amekawa ends his explanation of this part of his adaption of the framework by ensuring that any programme using this framework is also inclusive by facilitating interdisciplinary cooperation and emulating PRA approaches by focusing on building long term sustainable livelihoods (2011).

Agroecological multifunctionality

Amekawa's paper adapts a previous SLF diagram which explored agricultural multifunctionality (Amekawa et al. 2010). This term is defined as the 'incorporation of various commodities and non-commodities produced through farmers' agroecological practices into particular concerns of their livelihoods and rural development' (Amekawa et al. 2010: 210). It differs from diversification or pluriactivity[52] by meeting societal needs rather than financial ones (Amekawa 2011). So agroecological multifunctionality could involve, for instance: food security, conservation of land and animals, on-farm resource recycling, and using natural fertilisers and pesticides, thus protecting the soil, water courses, environment, and even human health (Amekawa et al. 2010). In Amekawa's livelihoods framework with its approach to rural development, multifunctionality is used as a definition for the concept of agricultural sustainability, in that a small scale farmer's livelihood can be maintained or increased via the extent of existing agroecological multifunctionality (2011). Comparing agroecological multifunctionality with Chapter 2's discussion on agroecology, it relates through similar techniques as those in 2.3.2 such as protecting the soil and improving soil fertility, conserving water along with the techniques mentioned to mitigate and adapt to climate change in 2.2.4 which therefore can improve a farmer or their community's resilience and thus meet societal needs.

Pluriactive sustainability

Amekawa puts agroecological multifunctionality as one of the two livelihood outcomes in his framework under the overall umbrella of pluriactive sustainability (with diversified off farm and non-farm income being the second). Pluriactivity could be confused with the terms diversification or multifunctionality, but they have slightly different definitions. As mentioned above, multifunctionality has a social focus

[52] This is defined in the following section on pluriactive sustainability

(Amekawa 2011), whereas diversification focuses on the farm level and those activities which relate to the farm by using its resources, and have an impact on the economics of the farm, but do not consist of any farm work (European Commission 2008). Pluriactivity considers the individual farmer or their household (rather than the whole farm) and the activities that they may undertake, agricultural or non-agricultural to make a living. This could include offering holiday cottages on the farm, contracting with another farmer, or working in a second job in an office off the farm (European Commission 2008). There could be limitations to viewing the system from only an individual level, missing influences revealed in a wider focus, but as Amekawa considers the broader system with multifunctionality and then narrows down to the individual with pluriactive sustainability, those limitations should be minimised when viewed through the whole framework.

Amekawa suggests that pluriactive sustainability could incorporate the diversification strategies of sustainable livelihood approaches, and multifunctionality strategies of agroecological approaches, thus creating an "integrated approach to rural development" (2011: 148), enabling farmers to secure incomes through diversification approaches whilst increasing their agroecological multifunctionality practices.

Whilst Amekawa's framework is designed for rural development of small scale farmers in less industrialised regions, it is also applicable to farmers in the UK, where 104,000 farms in 2016 were under 20 hectares (which is the smallest category in DEFRA's *Agriculture in the United Kingdom 2016)* (DEFRA et al. 2016: 7)[53].

Furthermore, most farmers experience similar vulnerability contexts of political, agroecological and socio-economic; one more recent is that of Brexit and its long term political and economic influences in the UK[54]. Whilst UK farmers can build their assets individually, there are opportunities to build them alongside other farmers in a

[53] The Farm Business Survey no longer classifies farm sizes by land area, instead calculating farm size by the number of full time equivalent workers on a farm (Sanderson 2011, 2012).
[54] This is discussed in greater detail Appendix 11].

participatory and inclusive manner. This includes opportunities where farmers gather to attend a farm walk and observe new or different farming methods. Moreover, as discussed in Chapter 2 and in the next section of this chapter, there are interventions in the UK that encourage participatory research and practice amongst farmers.

The next framework was designed for a Pacific Island context, so where the relevance to UK farms is not overly explicit, it is discussed in each section below.

Agroecology and Sustainable Rural Livelihoods Framework (ASRLF)

The following sections of this chapter examine each aspect in turn of the ASRLF, drawing out and correlating points that are relevant to farming in the UK. Addinsall et al. acknowledge Amekawa's integrated framework, along with DfID's, but feel that it was not necessarily suitable for stakeholders in the Pacific (2015). As a result, they worked with those stakeholders to create a new framework, which addressed issues that Pacific islanders experienced (see Figure 3-4 below[55]).

Despite this focus on the islanders, this thesis argues that there are correlations with UK farmers, from considering agroecology alongside sustainable rural livelihoods (of which both are applicable to the UK), to culture influencing and affecting everything. These are discussed further in the sections below, along with applicability to the UK.

This section first explores at the outer circle of Figure 3-4, the context of culture surrounding everything and its relevance to UK farming. It then examines the double lined arrows showing research processes and participation using examples from the Soil Association. The four circles are then considered in turn, transitioning between each one with the orange arrows, including through the central circle of assets. The vulnerability context is first, followed by the agroecological and sustainable livelihood

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activities. The institutional processes and organisational structures are discussed next, before the agroecological and sustainable livelihood outcomes are considered.

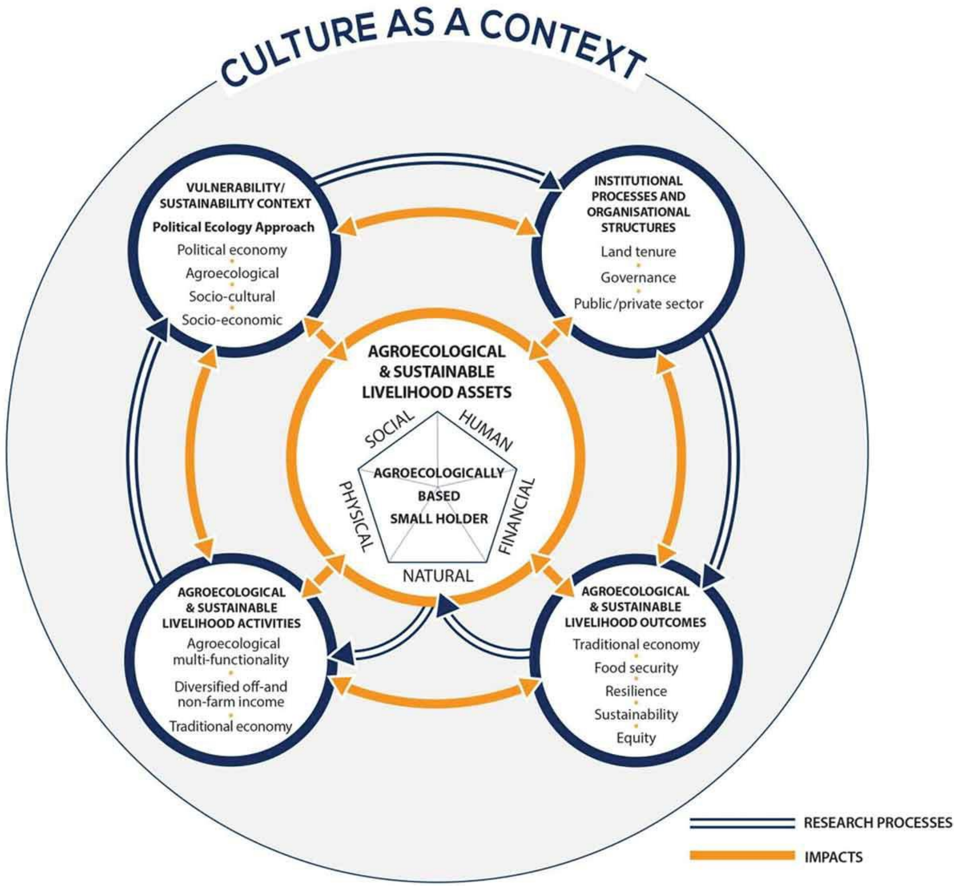

Figure 3-4 Used with permission[55] from (Addinsall et al. 2015: 707)

Culture surrounding everything

The most notable difference between this framework and the more traditional SLF is the move from a linear framework to a circular framework. This allows every part of sustainable livelihoods to be within the context of culture. Culture influences a person’s sustainable livelihood through their beliefs, identity, traditions, and language plus in the case of the ASRLF, their ceremonies, sacred sites and festivals (Addinsall et al. 2015). In the case of the Pacific, it can even affect vulnerabilities, making the islanders stronger[56]. Whilst the culture of Pacific islanders might appear to have little

[56] In the Pacific, culture and tradition can provide lifesaving results as shown by the Moken (a nomadic group of sea people) during the 2004 Boxing Day tsunami where they did not lose a single life (Arunotai 2006). Their local traditional oral knowledge of their ancestors enabled them to know that when the sea receded from the shore, they should run to higher ground (Leung 2005, Arunotai 2008).

relevance to UK farmers, they also have festivals (annual farm shows) such as the Royal Welsh (Royal Welsh Agricultural Society 2017), Three Counties (Three Counties Agricultural Society 2017) or Grassland and Muck show (Royal Agricultural Society of England 2017). Equally, belief and identity are important in shaping the way farmers behave (particularly with regards to environmental management) (Mills et al. 2016, Kings and Ilbery 2010). There are farming traditions such as attending a Young Farmers' club as a teenager (National Federation of Young Farmers' Clubs 2014), or visiting the pub with one's farming peers (Pub is The Hub 2016). Moreover, in another example of culture impacting on UK agriculture, farmers who choose to farm using alternative farming styles do not necessarily fit with the farming community where they farm, and those farming more conventionally may choose to not fully accept the alternative style farmer (Lobley et al. 2005, Home and Stolze 2016, Hosking 2012).

Research and participation

As part of the circular nature of the framework, research and knowledge transfer form a continual cycle of beginning, ending and restarting, with an analysis of a person's assets (Addinsall et al. 2015). As shown by the solid double arrows in the framework (Figure 3-4), each component of the ASRLF influences a person's livelihood as well as the other elements of the framework (Addinsall et al. 2015). Furthermore, recognising the importance of the traditional economy of the Pacific islanders and its relevance to livelihood activities and outcomes enables sustainable economic activity to operate at the household and individual levels alongside reciprocity amongst members of the community (Addinsall et al. 2015). Whilst the UK may not have an obvious traditional economy, amongst the farming community there are elements of it through farmers helping their neighbours with harvesting, and then the neighbour returning the help as needed (Emery and Franks 2012, Mills et al. 2011, Sutherland and Burton 2011).

In addition, the framework encourages informal research through the participation of the community in the research process, allowing them to analyse their livelihood assets by assessing how sustainable and agroecological they were, whilst each member could offer personal knowledge to tackle any complex problems the community faced

(Addinsall et al. 2015). In the UK, the Soil Association's Innovative Farming programme (Soil Association 2016) mentioned in Section 2.5.2 of Chapter 2, is a good example of farmers contributing towards research which would benefit their farming livelihoods. By improving their soil, or crop yield, or animal health, they increase the income and non-income factors of their livelihoods, such as improved wellbeing.

Vulnerability and sustainability context

Addinsall et al. add the term sustainability in the ASRLF to consider the linkages between the different levels (household, community, individual) of the agroecological small landowners and their wider geographical, economic, social, and environmental contexts. The links between the levels and contexts can encourage reflection on how changes to the community could influence the household, or the way that changes to the social context could influence the economic contexts. Four categories under their vulnerability and sustainability context in the framework are: 'political economic, agroecological, socioeconomic and sociocultural' (Addinsall et al. 2015: 713).

The agroecological and socioeconomic elements echo Amekawa's framework above, with the latter considering access to resources at three different levels, that of the individual, community and household, whilst the agroecological considers how the local and regional ecological circumstances relate to agroecological practices of farmers (Addinsall et al. 2015, Amekawa 2011: 145).

The political economic component is remarkably similar to Amekawa's description above, but it also considers that within the livelihoods of a group such as the Pacific islanders, the 'global financial crises were recorded as having little impact on the majority of rural families in the Pacific living a more traditional subsistence based lifestyle' (Addinsall et al. 2015: 713). Thus, the ASRLF considers the political economic vulnerability context to be relevant to the non-monetary aspects of the islanders such as the informal communities and culturally specific protection systems of the islanders' society. The specific impacts of vulnerability to the political economic arena are more relevant to impacts such as the adverse impacts of climate change on their society (Addinsall et al. 2015).

The concept of political economic in the ASRLF has little relevance to the UK farming community who are very vulnerable to economic changes including volatility in the markets (National Farmers Union 2015b, Veerman et al. 2016). In the UK, farmers were already experiencing financial difficulties from the late 1990's (Tulip and Michaels 2004). Yet, the agricultural sector began to improve economically after the turn in the century, only to face financial difficulty again in 2007 after the financial crisis (DEFRA et al. 2016). Since 2007, the farming sector has begun to improve its income, only to find profits fall by 29% in 2015 (National Farmers Union 2016a). The more general political economic category (alongside the other three categories and climate change), is more similar to the ASRLF. As mentioned previously, farmers experienced severe flooding over the winters of 2013-14 and 2015, resulting in animal loss and damage to their farms (National Farmers Union 2016b, Jones 2014) and many relied on forage aid (Forage Aid 2015), which could be argued as a non-monetary aspect of the UK farming community which enables them to be resilient to climatic vulnerabilities.

Agroecological and sustainable livelihoods activities

Addinsall et al. replace the term 'livelihood strategies' with 'livelihoods activities' as the authors believe activities include talks and workshops which have a time impact and benefit livelihoods, but might not have a monetary benefit (2015). Their framework 'recognizes how people's aspirations and values are reflected in their livelihood activities and outcomes and therefore highlights alternative development opportunities' (Addinsall et al. 2015: 711). The framework considers the traditional economy as one of the livelihood activities focusing on values; it can contribute to improving the wellbeing of a person without necessarily earning an income (Addinsall et al. 2015). Diversified off and non-farm income remains the same as Amekawa's description, and in the framework, considers those activities which do not appear under multifunctionality.

The last activity in the ASRLF is agroecological multifunctionality, which is discussed in detail in the previous section. However, unlike Amekawa's description, in the ASRLF, multifunctionality considers the non-monetary enterprises as equally important in providing for the wellbeing of a person (Addinsall et al. 2015, Amekawa 2011). It also highlights the multifaceted nature of the livelihood needs of the small farmers (Addinsall et al. 2015). Wezel and Jauneau state that the functions of multifunctional agriculture relate to the three pillars of sustainable development 'economic sustainability, social sustainability and environmental sustainability' (2011: 16). From this viewpoint, Lovell et al. suggest that agroecology and multifunctionality can help unify rural and community development (Lovell et al. 2010). Addinsall et al. state that 'from a livelihood stand-point agroecological multifunctionality could provide an all-encompassing view of sustainability that serves to maintain or improve small-scale livelihoods' (2015: 712), thus enabling agricultural sustainability to aid the socioeconomic and ecological purposes of those living in harsh circumstances with risk of environmental degradation (Addinsall et al. 2015).

Furthermore, despite including multifunctionality, Addinsall et al. chose to exclude pluriactive sustainability as the authors decided it did not make allowance for traditional economies as livelihood activities (2015).

Institutional processes and organisational structures

The categories for this part of the framework are land tenure, governance and public/private sector organisations, and the ASRLF considers how all three have a positive and negative impact on a person's ability to gain a sustainable livelihood (Addinsall et al. 2015). However, the framework also considers 'societal norms, gender roles and relations, informal and formal institutions, organizations and traditional policies, and provides strategies to strengthen network linkages (Addinsall et al. 2015: 714). Furthermore, the framework seeks to create and enlarge linkages between the farmers and the informal and formal institutions on the Pacific islands (Addinsall et al. 2015). This is similar to DfID's SLF which considers caste systems, and informal institutions (DfID 1999, Addinsall et al. 2015), but differs somewhat from Amekawa's framework by narrowing down to more specific processes and structures (Amekawa 2011, Addinsall et al. 2015).

Agroecological and sustainable livelihoods outcomes

The ASRLF states that key outputs are equity, resilience, 'sustainability (social, cultural, economic and environmental)' and 'a strengthening of traditional economy' (Addinsall et al. 2015: 714). The authors emphasise that to assess the success of the outcomes, the livelihood capabilities, assets and resources need to be discussed with the participants to see if they are agroecologically sustainable (Addinsall et al. 2015). These differ from Amekawa who has multifunctionality and pluriactivity as his outcomes (which the ARSLF has as activities), but also differ from DfID's SLF, in that the ASRLF considers resilience and equity as specific outcomes, rather being strengthened because of the outcomes. This in turn would improve the farmer's assets and help withstand vulnerabilities.

The framework 'seeks outcomes and opportunities' for agroecological farmers to take part in both market and traditional economies whilst maintaining a healthy ecosystem and encouraging an increase of resilience (Addinsall et al. 2015: 714). Whilst the UK does not necessarily have traditional economy as a livelihood outcome, resilience, sustainability and equity are all valid outcomes for UK farmers, whilst ensuring that the UK is food secure would require a strong reliance on UK farming rather than food from overseas, therefore also improving the livelihoods of the UK farmers.

The ASRLF, despite its setting in the Pacific, has relevance to the UK as discussed across the section. In particular, it considers the importance of culture, and how it relates to all parts of the framework such as improving assets or influencing activities that a farmer may undertake on and beyond their farm. It promotes participatory research amongst farmers, which can encourage peer-to-peer learning as is discussed in the results and discussion chapters (5-7). The framework also considers impacts of vulnerability beyond the SLF, looking at specific elements such as the political economic and how that can increase vulnerability. This is useful to consider as it emphasises those aspects of vulnerability that might not turn into a big shock, but instead merely erode the resilience and assets of a farmer, increasing the stress they may face. The ASRLF considers activities that might not increase the finances of a farmer's assets immediately, but through increased knowledge, improves their assets. This is encompassed into the needs category in the HULF below. Finally, the institutional processes and organisational structures are also important in both the SLF and Amekawa's framework, but also relate to the HULF and adapted diagram (see Figure 3-1) as they can help or hinder access to resources.

Whilst the last two frameworks are adaptations of DfID's SLF, Addinsall et al.'s agroecological sustainable livelihoods framework introduced a circular, interconnecting design (Addinsall et al. 2015) which begins to move away from the formal structure of the SLF, which is also an element of the HULF below.

As discussed in 3.3, livelihood frameworks do apply to UK setting. However, whilst the Household Urban Livelihoods Framework (HULF) also uses elements of the SLF, it also considers other differences, which could be argued make it more relevant to farmers and rural communities in the UK.

Urban framework for a rural UK setting?

The SLF and the two adapted frameworks are mainly focused on rural livelihoods in less industrialised regions, so they do not necessarily assume that infrastructure for resources is in place. The HULF (discussed below) was chosen as the framework to adapt for this thesis for these differences listed below, but also because the urban framework is most relevant to the British society. In the UK, most farmers in rural settlements are connected to resources such as electricity, water and telephone lines supplied by the government or private businesses in the same way that at the time of creating the framework only urban people in a less industrialised regions were connected to resources (Sanderson 2000). UK rural areas do still require oil or bottled gas being delivered and some still do not have broadband, but water, electricity and telephone access are common across most of the UK.

3.4.3 HULF

The household urban livelihoods framework (see Figure 3-5 below) helps to understand the drivers and barriers for individuals and communities to become resilient to shocks, stresses, and disasters. It was created by CARE International for vulnerable households in urban areas (Sanderson 1999), and looks quite different to DfID's framework (see Figure 3-2). The differences between the frameworks and the HULF are discussed below (Figure 3-5).

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure 3-5 From unpublished MA dissertation (Hartless 2008: 9) **adapted from** (Sanderson 1999: 3)

Differences between the frameworks

Household at the centre, and needs of that household

Whilst DfID state that they have people at the centre of the SLF (DfID 1999), the diagram has been pared down to the point where it is a diagram of shapes with nothing to overtly indicate that a person is at the centre of the framework rather than a pentagon of assets. Whilst this makes sense to some, for those who learn better through visual representations, the lack of a person at the centre can confuse[57]. The HULF specifically has a household at the centre, with everything flowing to and from that household (Sanderson 2000)[58]. The other two frameworks also do not overtly reference a household or people at the centre of the framework. This is despite Addinsall et al. creating the framework using participatory methods with the islanders who still have a pentagon of assets at the centre (Addinsall et al. 2015), and whilst Amekawa does reference farmers and landless people, it is via descriptions (Amekawa 2011). Whilst visual representations of people might not seem significant in such frameworks, they may serve as a graphic reminder (particularly for visual learners) that people are at the centre of sustainable livelihoods.

The HULF also considers the household's needs, which might be achieved through formal or informal access to resources. These are not overt on any of the other three frameworks. DfID's SLF can interpret that a person's needs might be part of their assets (such as needing money (financial asset) or shelter (physical asset). Whilst Addinsall et al. and Amekawa see needs as part of agroecological multifunctionality, which for both frameworks forms part of the activities (Addinsall et al. 2015) and outcomes (Amekawa 2011), rather than the basic human rights to water, housing,

[57] Learning in different ways such as through farm walks are discussed in more detail in Chapter 6 and 7
[58] It must be acknowledged that in Sanderson's later work, he has moved away from a household, to instead show people, and or groups of people (Gilbert et al. 1980). Whilst this thesis still uses the term household, it does whilst referring to a family or group of people and in Section 3.5 it refers to everyone on the farm, from the workers, to the family (QSR International 2015).

education and health (OHCHR 2017) which are also included in the United Nations 2015 -2030 Sustainable Development Goals (United Nations 2017).

Having the household or community at the centre is important to this research as holistic management principles (a form of agroecology as discussed in Chapter 2) promote the concept of the whole farm. This includes the household (children and partners are encouraged to participate in holistic management and agroecological farming practices too) thus requiring the whole family at the centre (Agroecology Research Group 2014b, Holistic Management International 2015).

Assets creating resilience to vulnerable contexts.

All three of the former frameworks assume that through building a person's assets, they will be less vulnerable to shocks and stresses (DfID 1999, Amekawa 2011, Addinsall et al. 2015). However, in the HULF, the visual image of the assets as a pentagon or hexagon unravels and turn into a wall that the household or community is protected, by their assets, from the hazards, shocks, and stresses (see Figure 3-6). The greater the assets, the stronger the protection and therefore the resilience of the household or community (Sanderson 2012). Relating this back to Chapter 2, through a farmer changing their behaviour and farming techniques towards those techniques, which can mitigate or adapt to shocks and stresses such as those from climate change, they can build up their assets, which in turn can improve their ability to access resources, or remain resilient to those shocks. This could be by transitioning to AaSF, or merely using the techniques listed in sections 2.2.4 and 2.3.2.

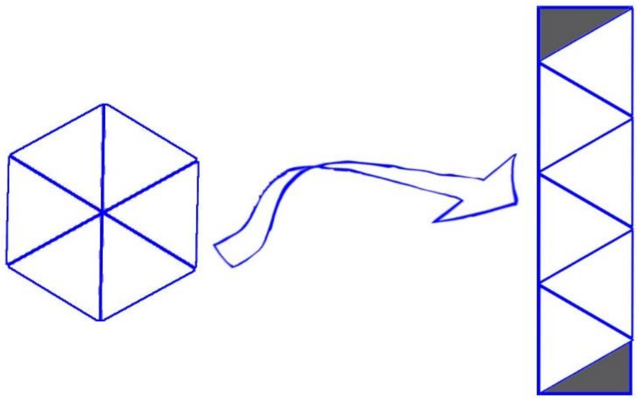

Figure 3-6 Hexagon of assets unravel to form the resilient wall

There is also a consideration that some assets are tangible such as physical (livestock for example), financial (cash) and natural (water) and therefore more easily convertible (sell an outbuilding and use the income to buy livestock), whilst others are intangible such as human (education and skills for example) and social (beliefs or social groups) (Sanderson 2011). Those that are intangible can be self-renewing and therefore are less likely to be destroyed in a hazard such as a storm.

Explicit barriers to accessing resources

Whilst the transforming structures and processes in the SLF, and the institutional processes and organisational structures of the ASRLF consider where those structures hinder access to resources to build assets, there is little overt reference in any of the three frameworks to barriers (DfID 1999, Addinsall et al. 2015, Amekawa 2011). With the HULF, the diagram aimed to show how for some households that CARE worked with, their culture, gender, caste or religion could disrupt the flow of access to resources, whilst those resources were also controlled by institutions (Sanderson 2012), so if one does not pay their fuel bill, they are unlikely to have heat. Whilst in the UK, it is less likely that gender, culture, caste, or religion would create barriers to farmers accessing resources; it is not impossible. Furthermore, lack of income, geographical location or even alternative farming styles can create barriers. These are discussed further in Section 3.5.3.

Further meanings of how the HULF relates to this thesis are discussed in the next section.

3.5 Going deeper into the HULF and how it relates to this research

The sub-sections below indicate how the HULF can be used in the UK, and its relevance to this thesis.

3.5.1 Shocks and stresses

As mentioned in Chapter 2, farmers in the UK experience vulnerability from a variety of shocks and stresses. Over the last decade, the UK has experienced a variety of extreme weather conditions. In 2010, The UK experienced the coldest December in 100 years

(Met Office Hadley Centre 2013), severe flooding in the south-west in the winter of 2013-14 and north of England in the winter of 2015-16 equalled the two wettest winters recorded (Met Office Hadley Centre 2016c), and in some parts of England 2016 had the wettest June on record (Met Office Hadley Centre 2016d). Furthermore, as discussed in 2.2.1, the last three years (2014-2016) have been the hottest on record, and as the climate warms we may see more climate records broken in the future (Blunden 2017). As discussed in 2.2.3, the warm weather was partially responsible for the flooding (Met Office Hadley Centre 2016b, McCarthy et al. 2016), which in term has impacted on farming in the UK with crops and livestock lost to floodwaters (Rural Payments Agency and DEFRA 2016).

In addition to the stresses mentioned in ASRLF vulnerability Section of 3.4.2, UK farmers have also had financial stresses such as delayed subsidies (Daneshkhu 2016a), and regulatory stresses from the banning of the pesticide neonicotinoid, which farmers were using on oilseed rape (Harvey 2016) to protect from flea beetles (Driver 2016, Farmers Weekly 2016a). Other stresses which have occurred include ill health of farm animals from TB (Brooks-Pollock et al. 2014), bluetongue (Skuce et al. 2013, Gale et al. 2009) and orf (Public Health England 2014, NHS 2016)), and financial trouble from market volatility (National Farmers Union 2015b, Veerman et al. 2016).
Other shocks and stresses could include the ill health of the farmer, their household or their animals, other financial factors, and anything abnormal or unexpected that would influence the farm household in a negative way.

The future potential lack of migrant workers (Sheffield 2016), along with changes to farming subsidies could also increase stresses over the next few years, as the country decides in what form it should leave the EU (Alston 2016). This is discussed in Appendix 11.

Some farmers may remain resilient to these impacts however, it is still possible for them to reach a point where they struggle with their day to day activities (Farming

Community Network 2013), whilst other farmers have left farming (AHDB Dairy 2017). Organisations such as Forage Aid, and the FCN provide help and support at those times (Forage Aid 2015, The Farming Community Network 2013). A study of farmers in the Peak District found ‘a very high prevalence of depression was found among male primary farmers; almost 8% reached the threshold for clinical depression’ (Syson-Nibbs et al. 2006: 225) whilst farmers in Devon have suffered from social isolation, stress and depression following financial difficulties resulting from the foot and mouth outbreak (Lobley et al. 2003). These examples of shock and stresses can reduce a farmer’s human and social assets, which can reduce their resilience to future shocks.

Hence, it is important for UK farmers to build up their assets to enable them to become less vulnerable and withstand whatever difficulties may appear.

3.5.2 Farm household and assets

Using the HULF for UK farmers, the makeup of each asset differs in some circumstances from DfID’s SLF, but not in others[59]. The five capital assets framework has been used in the UK and describes the contribution to community assets as: ‘Natural Capital: goods and services provided by nature; Financial Capital: the stocks and flows of finance; Physical Capital: infrastructure utilised; Human Capital: individual skills and knowledge; and Social Capital: interactions and cohesiveness of communities’ (Delow and Couzens 2003: 3). These assets can intersect each other for example through interacting with other people, a person could also increase their individual human knowledge. These descriptions summarise each asset and are used as definitions for this thesis. The assets are discussed in more detail below, adapted from an amalgamation of articles (Hocking 2003, Ponder and Hindley 2009, Oxfam

[59] Whilst the HULF contains a sixth asset ‘other stuff’, in this thesis, any aspect that may have fitted into ‘other stuff’, is also placed into the social assets category and is discussed above

Cymru 2013, May et al. 2009, Delow and Couzens 2003, Saltmarsh et al. 2011, Sanderson 2012).

Human assets

The human assets look at the skills of the farmer and their household community, their health, education and knowledge, confidence, and soft skills (such as time management, decision making and communicating with others). Whilst a farmer may only have knowledge applicable to farming their land, they could, for example, have family or friends who are happy to share vehicle maintenance skills which can be used to repair the farmer's machines or even share machinery itself (Roomi and Redman 2016, Winter and Lobley 2016, Lobley et al. 2005). The health of the farmers can hinder their work, but unless it is serious and stops them from doing the job, they may continue to farm. In the UK, many farmers previously may not have had extensive schooling, but they have encouraged their children to stay in school, and some farmers complete other skills training which can bring in further income (Bowler et al. 1996, DEFRA 2013).

Financial assets

The financial assets have already been mentioned in the shocks and stresses section above, but receiving subsidies would strengthen the financial asset as well as weaken it when they did not arrive (Daneshkhu 2016b). By receiving the subsidy annually, it could create a reliance on that money. This could prove unhealthy to the farmer's financial assets if there was nothing in place to sustain the loss of that income should the subsidy fail to arrive.

Income and diversified income, or savings and wages from off farm jobs could also help strengthen the asset aside from the subsidies (Morris et al. 2017, Hennessy and O'Brien 2008, Hill 2009). Land and buildings capital would as well, if it was owned and not rented (Lobley and Potter 2004). This links to the physical asset through the creation of income from selling or renting equipment or buildings owned (Oxfam Cymru 2013).

Physical assets

The physical assets would include the farm buildings as places for use rather than financial capital (Hocking 2003), such as for milking cows, storing grain or to live in. However, Ponder and Hindley report that buildings can also impact on the financial asset through high maintenance costs, whilst many farm buildings are actually unsuitable for modern farming (2009) and not necessarily sustainable. Machinery and transport that is owned or shared amongst a community can also be a physical asset, although some farmers may not see machinery or livestock as an asset, whilst other physical assets could include possessions (Hocking 2003, Pretty et al. 2005). These would include access to information via a computer that the farmer owned and equally if the farmer had used their finances to pay for communication services, the access to those services would become a physical asset (May et al. 2009).

Natural assets

Natural assets have been described differently across UK literature. Hocking describes it as public assets including utilities (Hocking 2003), whilst Oxfam in Wales include natural assets and physical assets as one, and have public assets as the separate asset (Oxfam Cymru 2013). The other articles with their focus on food and food production, still have natural assets individually (Saltmarsh et al. 2011, Ponder and Hindley 2009, Dowler et al. 2004, Delow and Couzens 2003), and as this thesis has its focus on farming, it will also use natural assets, with public assets falling into the 'social assets' section. Considering the natural assets, they include natural capital and ecosystem services such as air, water, soil, sun, and weather (Amekawa 2011). Regarding air, its quality would be better in rural parts of the UK, but not necessarily for urban farms (Bell et al. 2011, Carrington 2016). Water availability and quality such as streams, wells and springs on the farm (rather than piped water from a utility company) are a natural asset and would also include rain collected to be used on the farm (Scherr et al. 2012, Gliessman 2015). However, rain could also be a problem if it fell at the wrong time, or excessively (National Farmers Union 2014a, Parry et al. 2013) . The quality of the soil, which can be improved through agroecological techniques as discussed in Chapter 2, such as improving soil fertility and sequestrating carbon (Elliott et al. 2016), and the topography of the farm (is it hilly, flat or a floodplain) can be an advantage or disadvantage (Skinner et al. 1997). Agroecology also considers other ecosystem services such as weather and environmental conditions including how much sun the farm gets, farm orientation and overshadowing of, or shady fields (Gliessman 2015), wind and windbreaks, and hot and cold weather (Altieri 1995). These can also benefit more conventional agricultural production (Pollock 2011).

Although good seasonal weather can help strengthen assets through the growing of crops, poor seasonal weather may induce shocks and stresses. Wildlife, animals, insects and birds can help the biodiversity of the farm (Pimentel et al. 1997, Thrupp 2000) and be utilised with agroecology. However, they can also negatively impact an asset through, for instance, foxes killing chickens (Maxey et al. 2011), or badgers infecting cattle with TB (Brooks-Pollock et al. 2014), or pests attacking crops.

Social assets

The fifth asset is social, the social capital that includes a farmer's relationships with family and friends (Fisher 2013), their social networks such as formal farmer groups and informal networks (Saltmarsh et al. 2011), the cohesiveness of the farming community (Delow and Couzens 2003) and (reflecting C2.4.3) the 'norms, values and attitudes' (Pretty 2003: 13) which can influence a farmer's behaviour. Social capital can also include elements of reciprocity (as discussed in 3.3) (Sharp and Smith 2003), faith groups (Saunders 2008, Ponder and Hindley 2009) or social activities such as visiting the pub (Oxfam Cymru 2013). Sharing machinery when a neighbouring farmer's tractor has mechanical problems, or helping physically on the neighbour's farm in an emergency can also help build a farmer's social asset (Sutherland and Burton 2011).

However, in addition to the above, the social assets for this thesis also include: public sector services which a farm household may require such as education, health and emergency services (May et al. 2009), political issues such as the NFU (Curry et al. 2012) and other organisations pushing for political change, and the right to vote in a democratic society (Sanderson 2012). Social assets would also include other services such as public transport, parks and utilities (Hocking 2003) which once paid for can help strengthen a farming household's assets.

Of the assets above, some contain elements that are self-renewing such as the different seasons in the natural assets, or wages from diversifying, such as letting holiday cottages on the farm, in that as long as they continue to be let, they will continue to generate an income. Looking at the assets above and reflecting on the *explicit barriers to access* section above, it is also worth considering the debate over private and public assets such as where a farmer gets the right to be treated at a GP practice or hospital if they injure themselves. Is it because they have financial assets to purchase those services (either straight off, or via national insurance), or should they be provided free by the state?

Reflecting on behaviour change, as farmers change their behaviour to use new AaSF techniques, those techniques can then improve the natural asset, or physical and financial assets. Those assets then improve the ability to access resources as discussed below.

3.5.3 Resources and services: access to them, barriers to accessing those resources and informal access

Farmers, their households and their community need resources for their day-to-day farming lives. Resources can provide inputs for a farmer (fertiliser, piped water or seeds for instance), help build their assets (the education system would build a farmer's child's knowledge and therefore their human assets) (Gasson 1998, Garforth 2011) and provide services such as support from the NFU, or subsidies from DEFRA (2015c), and access to the NHS and emergency services. However, in order to access the public sector service resources that are provided free of charge such as health or their state pension, farmers need to pay their national insurance, income and council tax contributions (The Money Advice Service 2016, Elvin and Which 2016, Wright 2012). In addition, for resources such as water and sewage, food, electricity and heating, and seeds and chemicals for farming, those resources can only be accessed by paying for the resources (Black 2017).

Some farmers have invested in renewable electricity, heating and water systems, so they no longer have to pay so much, if at all for the above resources (Macalister 2012, AgriChatUK 2016). Some may even have become self-sufficient or even gone off grid, recycling their waste, water or sewage, supplying their own seeds or animal feed and using organic approaches rather than chemicals (Brithdir Mawr Community 2016). However, this is not overly common across the UK, let alone in the agricultural sector, with most off grid communities forming communes that may farm, but focus more on the whole ecological, sustainability principles than saving money by living off grid (Lackan Cottage Farm 2016, Rosen 2014).

If a farmer or their household are unable to pay for their required resources (Parr 2016) and services (such as seeds, fertilisers or electricity), the institutions providing those resources and services can cut off access to them (Horne 2017), as finances provides both access to resources and barriers to resources, depending on whether finances are available or lacking (Sanderson 2000). Another element (discussed in Chapter 2.5.1) that could improve or restrict access to resources is agricultural policies, which, for instance, might reduce subsidies if a farmer was farming without consideration of the environment. Other barriers could include farmers from agroecological farming styles being excluded from accessing seeds or sales due to perceptions or lack of understanding about that farming style (Hosking 2012). Furthermore, as described in Hosking's article, some services such as council allotment schemes may not consider a permaculture farmer as suitable to grow vegetables on the council's allotment (2012). Equally, due to geographical location some utilities are not suitable or available, so farmers in more rural and remote areas would need to have access to alternative methods for heat, or communication (McGhie 2015).

For a farmer in a less industrialised region, there may be informal access (bypassing barriers created due to race, caste or gender) to needed resources, such as using income gained from the informal economy to buy seeds, or local urban people tapping an electricity line to get 'free' electricity (Smith 2004, Depuru et al. 2011). However, in the UK, this is far less likely and the only informal access would be from a form of reciprocity, bartering, or sharing food amongst neighbours or possibly working for cash in hand (Sutherland and Burton 2011).

Whilst the points above exist on the original HULF, the next section examines how the HULF can be adapted to be more specific for farmers in the UK.

3.6 Adapting the HULF for a UK rural context

3.6.1 Differences, changes, why…

The UK Rural Livelihoods Framework at the start of this chapter Figure 3-1, which has been adapted from the HULF, with elements from the other three frameworks, includes differences applicable for a UK farm household. The green input and output arrows to and from the farmer household include livelihood activities or strategies which can help with accessing resources (Addinsall et al. 2015), they are also (much like in Amekawa's framework) influenced by policies and resources (Amekawa 2011). The modified analytical framework considers that a farm household would harvest their crops to sell, or work in a diversified role (on or off farm), thus creating income to access the resources, which then enables them to buy seeds or fertiliser to help grow more crops. However, these inputs and outputs (which also help strengthen the assets) can also have an impact on shocks and stresses so are discussed in detail below. Furthermore, like with Addinsall's framework, the resources, services, processes and inputs also considers governance and policies (2015) as those can effect and control resources. Finally, the needs of the farm household are more complex than in the HULF as a farmer in the UK also needs energy to provide transport, electricity and heat for their equipment, buildings and other farming processes.

3.6.2 Needs of the farmers

The needs shown in Figure 3-1 at the beginning of this chapter do not include the full list mentioned below, as some needs are assumed such as shelter (OHCHR and UN Habitat 2009). Others fit into one of the six listed needs in the Figure 3-1 – water, health, education, food, energy and communication. So, for instance, energy could include any form of energy from transport and heat, to electricity.

For a farmer in the UK, both their farm and their family household have needs. For example, for the farm, they would require shelter, food for the animals, water, electricity, heating and fuel to run machinery, seeds, fertilisers or pesticides for the crops (natural or chemical), electronic communication (if they are using techniques such as precision farming,[60] and the knowledge and education to successfully grow crops or rear animals, ensuring the good health of either. Some of these needs are provided by natural on-farm inputs such as rain and heat from the sun, whilst others are provided from off-farm inputs such as fuel. For those that are accessed off farm, the assets and farm outputs can help provide income to access those resource outputs.

3.6.3 Farm outputs

As part of the farm system, each farm household would produce outputs that can improve or reduce assets, and influence hazards. Furthermore, through AaSF and climate-resilient farming techniques, some of the outputs would increase, whilst

[60] as this requires GPS

others would decrease. Using a typical conventional farm as the example, the table below (3-2) draws upon (van der Werf and Petit 2002, Pacini et al. 2004, Agroecology Research Group 2014, FAO 2013, Dixon et al. 2001, Pretty et al. 2005, 2000, Gliessman 2015, Crowder et al. 2010, Pimentel et al. 2005, Arnell et al. 2015, Skinner et al. 1997).

Table 3-2: Farm outputs and how they interact with hazards and farm assets

Outputs	How can hazards, shocks and stresses influence the outputs?	How can outputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Goods to sell (such as crops, meat, dairy, energy)	Climate hazards such as rising temperatures or flooding could reduce the crop yield, or other goods	Through the increase in consumption of meat and wheat, more production of those goods creates more emissions, which are discussed below.	They can reduce yield of crops initially, but over time the improvement in the soil, quality can increase the yield (and therefore the goods produced), thus increasing natural, social and physical assets. Also improves financial asset.
Waste (solid or liquid)	Hazards unlikely to influence unless sewers overflow in a flood	Manure waste or landfill can cause emissions (see below)	Decrease due to paying for disposal (reducing financial asset), and could harm natural or physical assets for example by leaching and running into waterways. AaSF would reduce the impact of waste by utilising the waste on the land providing natural inputs either to fertilise land (improving natural asset) or to produce energy, improving, or reducing the amount of waste produced (reducing hazard).
Emissions (from machines and transport, animals, disturbing soil)	Excess hot or cold temperature from a changing climate could increase the use of machinery to heat or cool on the farm, potentially releasing more emissions.	Can add to GHGs, (impacting on climate, or weather hazards)	They would work to reduce emissions that would increase the hazards through improving air quality and potentially mitigating against climate change.

Outputs	How can hazards, shocks and stresses influence the outputs?	How can outputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Water	Climate influenced lack of rain or increased rain can impact	Fertilisers and pesticides (alongside other sources such as road run off) can drain into waterways and cause eutrophication or acidification.	Improving soil structure can store more water thus benefitting in drought conditions and potentially reducing water drainage thus increasing physical and natural assets; AaSF do not use fertilisers or pesticides that would harm the land or water.
Land maintenance: including improving the environment by planting trees or building soil organic matter.	Flooding can cause landslides and water logging whilst a lack of rain could create a drought which would reduce the ability to maintain the land and improve the environment.	If land is well maintained with trees and good soil quality it is less likely to flood or become water logged, and trees could prevent landslides.	Ensures natural assets and physical assets remain strong if land is maintained properly. As mentioned above and left, improving the soil quality as part of AaSF and climate-resilient land management would improve natural assets, but also reduce the loss of financial assets through improved yields and less disease from better maintained land.
Flora and Fauna habitats	Weather and climate related hazards could destroy any habitats	Animal habitats such as badger sets or rabbit warrens can cause agricultural land to subside, whilst badgers can potentially cause TB in cattle, contributing to stresses.	Agroecology principles encourage reducing impact on flora and fauna on a farm, so can improving natural assets by increasing biodiversity. Social or human assets may be increased via improved quality of life.

Outputs	How can hazards, shocks and stresses influence the outputs?	How can outputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Beauty, green and pleasant land	As shown by the flooding in Somerset in 2013-14, climatic influenced hazards can temporarily or more permanently mar the beauty of the natural environment.	Controlling land for agricultural farming can potentially make it more susceptible to causing hazards, such as deforestation increases the likelihood of flooding and landslides.	Some conventional farming techniques may destroy the beauty of the landscape thus potentially reducing social and human assets. AaSF farming should increase natural assets and reduce hazards through re-establishing natural relationships, which previously have occurred on the land, before cultivation.
Services (such as renewable energy production feeding of the National grid, or farm contracting)	An increase in storminess could reduce the income from electricity generation via renewables such as photovoltaics, or reduce time spent contracting.	Whilst most services might not contribute to hazards directly, potentially if a farmer was contracting elsewhere, they then might not be able to stop a hazard happening on their farm.	Generally, these would have a positive impact on the financial assets. However, there would also be a cost outlay purchase renewable technology or to maintain the machines for contracting as they would be used more frequently that on individually on their own farm, so that could reduce the financial assets. Contracting could also contribute to social assets, as the farmer would be working alongside other farmers and possibly their friends.
Advice and education (given by farmer and members of their household to other people)	Hazards such as bad weather, or increase in rain or storminess could reduce the ability for the farmer to share their knowledge with other people via farm walks	If a farmer offers advice that harms the environment regarding any of the above outputs, it could impact on hazards	AaSF principles encourage empowering the local community, sharing new knowledge, encouraging consumers to engage with the farmers, and local communities to work together. Can help contribute to other farmers' human and social assets, which can help them improve their financial and physical assets. Could also increase knowledge of where food comes from and nutrition

3.6.4 Off and on-farm inputs

As part of UK Rural Livelihoods Framework Figure 3-1, inputs are brought to the farm household by accessing resources, but also through the global commons of the environment (rain, and sunlight for example) (van der Werf and Petit 2002). Those inputs can then help with the activities of farming, but can also help with the farmer household's needs, and in strengthening their assets. However, some inputs can also contribute to hazards, shocks and stresses, for instance chemical pesticides could pollute the local waterways, thus stressing a farmer's water supply (Kay et al. 2012, McGonigle et al. 2012, Arnell et al. 2015). Hence, it is important to keep the farm systems homeostatically balanced. Using a typical conventional farm as the example, the Table 3-3 below draws upon the following articles to explain this: (Dixon et al. 2001, van der Werf and Petit 2002, Gliessman 2015, FAO 1994, Arnell et al. 2015, Ponder and Hindley 2009, Pretty et al. 2005, Brentrup et al. 2004, Skinner et al. 1997, Dalsgaard and Oficial 1997, Gilbert et al. 1980, Tellarini and Caporali 2000, Cox 1984, McGonigle et al. 2012, Kay et al. 2012, Pimentel et al. 2005, Hart 1984).

Table 3-3: Inputs to the farm and how they interact with hazards and assets

Inputs	How can hazards, shocks and stresses influence the inputs?	How can inputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Nature - water	Climate change could increase or reduce rainfall to the point of crop damage, flooding or a drought.	Excess rain could wash fertilisers and pesticides into waterways, pollution the waterways and causing acidification or eutrophication.	Many farm households also have piped water on their farms, but this does depend on geography and finances. Thus as lack of rainfall could require more piped water and thus reduce the financial asset. AaSF and climate-resilient farming would increase assets through reducing water usage, and increasing the soil's capacity to store water, thus strengthening the financial and natural assets.
Nature – temperature	Abnormal weather patterns from climate change such as very late frosts in the spring, or excess warmth in the winter can influence crop or grass growth.	As the global temperature increases due to climate change, it is increasing the number of extreme storm events.	Farmers could adapt the crops their plant to ones which are better suited to the different temperatures, but given weather forecasts are not overly accurate in the long term, this is not easy to predict. If a farmer could, then this would ensure that their financial and physical assets would not reduce from a lack of crops. However, if not, they would be negatively impacted by changing temperatures.

Inputs	How can hazards, shocks and stresses influence the inputs?	How can inputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Nature – sunlight	Crops need sunlight to grow. So, a significantly wet summer with lower sunlight may affect crop growth. However, climate change might increase the hours of sunlight in the year and have a positive effect on crops.	The increase in GHGs is increasing the amount of sunlight that is being trapped on Earth, thus increasing the global temperatures, and therefore impacts of climate change.	Agroecological farmers might plant different crops that cope with reduced sunlight thus increasing the physical and financial assets. However, as it is difficult to forecast the sunlight for the forthcoming year that a farm will experience, it is unlikely that even an AaSF and climate-resilient farmer would have seeds for shade resistant plants, thus a lack of sunlight on a large field of crops over the summer would possibly reduce those assets, much like with conventional farming.
Nature – insects (Farmers need insects for pollination. However, other insects can harm crops or animals)	Thus, an increasing climate might increase the number of insects around which harm crops or animals. Alternatively, an increasing climate could reduce the number of bees and other pollinator insects.	In a cyclical way, as temperatures increase (hazard), it could increase insect activity and migration of insects' further north. Those insects could then destroy a field of crops (stresses).	AaSF and climate-resilient farming would encourage plants which boosted 'helpful' insects such as bees and other insects which would pollinate the crops and eat the destructive insects. farmers could find their natural assets reduced if they choose to use chemical means of reducing the insects that harm their crops, as the chemicals could reduce soil and water quality, which in turn would reduce crop outputs in the future (reducing financial assets).

Inputs	How can hazards, shocks and stresses influence the inputs?	How can inputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Nature – wind / air / atmosphere	If climate change increased the number and strength of storms, it could increase wind speeds and damage crops or erode soil.	Wind can erode bare soil, leading to landslides during excess rain. More pollution in the air influences crop growth, but also increases the likelihood of climate change.	The wind can provide air movement that could mix any air contaminants thus diluting them (increase natural assets). Furthermore, grain crops are wind pollinated, so farmers need the wind to grow their crops to increase their physical and financial assets)
Chemical and mineral fertilisers / pesticides	As described above, natural hazards such as an influx of harmful insects can damage crops. This would encourage more chemical or mineral pesticides	Fertilisers and pesticides can drain into waterways and cause acidification or eutrophication.	AaSF would reduce the impact of chemical fertilisers by utilising the waste on the land, providing natural inputs to fertilise land (improving natural asset), along with using other natural nutrients for fertilisers and pesticides. This would possibly initially reduce crop yields and therefore financial and physical assets, however it would increase the natural and human assets due to the reduction in pollution.

Inputs	How can hazards, shocks and stresses influence the inputs?	How can inputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Food (human and animal)	Increases in hazards such as flooding and drought can impact on future food supplies as crops are destroyed	As the population increases, more food will be required, which is likely to push production that is more intensive. This could then fuel more hazards and potentially more diseases requiring more antibiotics.	AaSF and climate-resilient farming would encourage a certain level of self-sufficiency at least for the livestock, thus sustaining the financial asset. Furthermore, food can help keep the household healthy increasing the human asset, and through sharing the food with friends increase the social asset.
Health and medicines / antibiotics (human and animal)	Climate change can increase diseases impacting livestock in the UK. Equally, hazards in farming can increase stress levels of the farmer, potentially reducing their mental health.	As more antibiotics are used on animals, along with the increase in industrial farming of animals, zoonotic and antibiotic resistant diseases could enter the population, potentially creating health hazards.	AaSF reduces the use of intensive animal farming and overuse of antibiotics, so should reduce the health risks from that farming style. Furthermore, holistic management looks to the whole, including financial planning and considers potential shocks, so the household should be better insulated to cope with health hazards. Whilst some farmers may not require medicine or health services, most at some point will require treatment from a doctor or hospital and this could impact on their human or financial assets. Furthermore, their farming style might not reduce stresses that would reduce human assets.

Inputs	How can hazards, shocks and stresses influence the inputs?	How can inputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Energy	Storms could pull down electricity pylons and cold periods of weather would increase energy used for heating.	In a cyclical way, the energy use creates emissions which contribute to climate change and other hazards	Climate-resilient farming would encourage reducing fossil fuel use for energy in favour of renewables or passive heating, thus increasing the financial asset. However, most of that would require an initial outlay, so for a certain period the financial assets would be reduced.
Seeds	The newly planted seeds could be damaged by flooding and heavy storms	Production and transport of seeds would increase emissions, plus requirements for inorganic fertiliser would also increase emissions, thus increasing the likelihood of climate change.	Purchase of seeds, plus any relevant fertilisers or pesticides would reduce the financial asset,. AaSF principles encourage saving seeds from previous harvests, or buying organic, thus not needing inorganic fertilisers. In the long term, this would improve the financial, natural and human assets, but organic seeds may cost more than conventional seeds, thus initially reducing the financial assets.
Machinery and transport	Excess hot or cold temperature could increase the use of machinery to heat or cool on the farm, potentially releasing more emissions. Bad storms could potentially damage machinery.	Can add to GHGs through producing emissions (impacting on climate, or weather hazards)	Agroecology would work to reduce emissions that would increase the natural hazards through improving air quality and potentially mitigating against climate change. It would also dis-encourage excess use of machinery (increasing financial assets), but employing more labourers would reduce the financial assets

Inputs	How can hazards, shocks and stresses influence the inputs?	How can inputs contribute to hazards, shocks and stresses?	Will AaSF and climate-resilient farming enable increases or decreases in the assets?
Services	Storms and bad weather could reduce electricity generation via renewables such as photovoltaics, or reduce time able to employ contractors.	Power generation from fossil fuels to provide electricity or fuel would produce emissions that could affect climate change.	Generally, these would have a positive impact on the financial assets. However, there would also be a cost outlay to pay the contractors. Contracting could also contribute to social assets, as the farmer would be working alongside other farmers and possibly their friends. This would most likely have similar impacts as conventional farming, although agroecology encourages using renewable resources, so a farmer farming agroecologically would be more likely to have renewable energy production.
Labour and management	Flooding could hinder employees getting to the farm. Stresses in finances could reduce the ability to employ help	To many contractors using tractors would reduce the time spent harvesting for example, but would also increased the amount of emissions, thus impacting on climate change. Lack of foresight or environmental sustainability thinking in management could encourage the excess use of nitrogen that could leach into the waterways, influencing water supplies.	Generally, these would have a positive impact on the financial assets. However, there would also be a cost outlay to pay the contractors. Contracting could also contribute to social assets, as the farmer would be working alongside other farmers and possibly their friends. Unfair pay of employees, or harsh management would reduce social assets, however agroecology would encourage fair pay, reducing financial assets, but increasing social assets.

3.7 Summary

This chapter has built on the context and theory discussed in Chapter 2 (as diagrammed in Figure 2-3, and considered sustainable livelihood approaches and how they relate to agroecology and the UK. Looking first at how sustainable livelihoods would apply in industrialised regions and particularly in the UK agricultural sector, the chapter explored how different authors and organisations have suggested its relevance in more industrialised regions, and adapted it to a UK farming context.

The chapter then moved on to look in more detail at four livelihoods frameworks, considering initially DfID's SLF with its vulnerability context, assets, institutions, livelihoods strategies and outcomes. Whilst the SLF explored the situation of rural people in less industrialised regions, the next two frameworks were applied to agroecological farming, and discussed the differences from the SLF, but also the relevance to UK farming. The last framework was the HULF, which whilst designed for urban livelihoods in less industrialised regions, had the closest similarities to people living in rural parts of the UK.

The chapter then looked specifically at adapting the HULF for the UK farming sector, exploring any shocks and stresses farmers may experience, along with examples of each asset, and how they can access resources. Finally, the chapter discussed the adapted version of the HULF for UK Rural Livelihoods Framework Figure 3-1 looking at the specific changes, from farmer needs, to farm inputs and outputs.

The next chapter critically explores the rationalisation for the approach taken to researching this topic through the methodology and collection of data. The results of that data collection are then discussed in Chapters 5 and 6.

Chapter 4 - Methodology and data collection

4.1 Introduction

A variety of methodologies and methods are used in research. Some are more relevant to the specific research questions considered in this thesis than others, so it is important that each is discussed. Initially, this chapter restates the aim and research questions for this research, before discussing paradigmatic, ontological and epistemological viewpoints along with the main theories behind quantitative and qualitative research. It will then examine where and how mixed methods can bridge the gap between the quantitative / qualitative divide, and the relevance of this approach to this research. Following this, the chapter will examine the proposed research design, beginning with a discussion of the stakeholder analysis of potential influencers of change to more agroecological practices (found in Appendix 2). Finally, the chapter will explore the research objectives (as measures to meet the research questions) and the actual methods for the research along with the background and context of the stakeholders in the field, the preparation and undertaking of the data collection, and a discussion of the two data collection stages, an online survey and semi-structured individual and group interviews.

4.2 Research aim and questions

4.2.1 Aim

To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities and livelihoods.

4.2.2 Research questions

1) What are the characteristics of agroecological interventions for building climate-resilient farming communities and ensuring sustainable livelihoods for UK farmers?
2) What are the drivers and barriers to behaviour change in farmers towards using more agroecological practices to build climate-resilient farming communities?

3) What are the implications of such changes for the UK food system?

4.3 Full description and justification of research design and methods

Understanding the philosophies underlying the methodology for the research and data collection being undertaken helped build the foundation on which to structure the research design. Thus, this section first examines philosophical paradigms, epistemology and ontology; it then considers the quantitative, qualitative and mixed method debates, before exploring the methodological viewpoints underpinning mixed methodology.

4.3.1 Discussion on paradigms, epistemology and ontology

Creswell uses the term 'worldview' with a definition coming from Guba as 'a basic set of beliefs that guides action, whether of the everyday garden variety or action taken in connection with a disciplined inquiry' (1990: 17). Creswell states that others use the terms paradigms, epistemologies and ontologies, or generally envisaged research methodologies to mean the same as his term 'worldview'. He further asserts that his interpretation of worldviews is 'as a general orientation about the world and the nature of research that a researcher holds' (Creswell 2009: 6). The worldviews are shaped by the topics the researcher is studying, the beliefs of that researcher, their advisors and faculty, and previous research knowledge (Creswell 2009).

In their overview of the *Handbook of Mixed Methods in Social & Behavioural Research,* Teddlie and Tashakkori mention that whilst authors in the handbook do not necessarily use the word paradigm, they explore issues central to the theoretical foundations of social exploration. These include 'epistemology (beliefs about the nature of knowledge, including those related to the objectivity / subjectivity dualism); axiology (beliefs about the role of values or ethics in conducting research); and ontology (beliefs about the nature of reality)' (2010: 4).

Johnson and Onwuegbuzie assume a paradigm is the overarching umbrella term for 'beliefs, values and assumptions that a community of researchers has in common regarding the nature and conduct of research' (2004: 24). They include (under the paradigm umbrella) beliefs stemming from ontology, epistemology, axiology, methodology and aesthetics (Johnson and Onwuegbuzie 2004).

Bryman suggests that epistemological issues reflect on the questions of what is considered as acceptable knowledge in a subject area, and that 'questions of social ontology are concerned with the nature of social entities' (2008: 18). However, he only briefly mentions paradigms when he explores mixed methods research (see 4.3.2 below).

Morgan offers a different discourse, examining human intervention over the content of paradigms, and suggests that if the substance of the paradigm is subject to such intervention, then there is little significance in claiming that the principles of epistemology, ontology and methodology are the defining characteristics for that paradigm (2007).

Discussing the above interpretations of worldviews and paradigms helped to clarify the beliefs and understanding shaping this research. Given the worldview of its author, that human made climate change is a reality and will influence food security as the population grows, hence farmers need to adapt in order to sustain their livelihoods and ensure food production, Morgan's approach is the most applicable, in that human activity, which is the focus of the research, is far more likely to form the character of a paradigm than philosophy.

The different debates on research methods (quantitative, qualitative and mixed) are discussed below to give a context, before a more detailed examination of the specific paradigms that underpin mixed methodology and its relevance to this research is conducted.

4.3.2 The quantitative / qualitative divide and mixed methods.

For over a century, research was broadly divided into two camps (Johnson and Onwuegbuzie 2004). One camp was focused on quantitative design and the underlying scientific paradigm underpinned by positivism or post-positivism with its 'deterministic philosophy in which causes probably determine effect or outcomes' (Creswell 2009: 7). Beginning with a theory, the researcher then moves to data collection that might either support or contest that theory, before the researcher revises the theory and makes further tests (Creswell 2009). Morgan states that positivism was labelled the dominant quantitative paradigm in the 1970's after qualitative research began to gain prominence, and states that it was not uncommon for the predominant paradigm to 'lack both a well-known label and a clear characterization of its content- until that existing system is called into question by a set of challengers' (2007: 56). Bryman avoids stating explicitly that positivism underpins the scientific paradigm, and instead argues that positivism occupies an epistemological stance that promotes the use of 'the methods of the natural sciences to the study of social reality and beyond' (Bryman 2008: 13).

The second camp focused on the qualitative design and underlying qualitative paradigm (Johnson and Onwuegbuzie 2004) underpinned by constructivism or interpretivism in which individuals look to understand the world in which they work and live (Creswell 2009). 'The researcher's intent is to make sense of (or interpret) the meanings others have about the world' (Creswell 2009: 8), or 'to understand the multiple social constructions of meaning and knowledge' (Robson 2002: 27), with researchers mainly using qualitative methods such as interviews and focus groups. Bryman associates interpretivism with epistemological considerations (2008); and avoids stating that constructivism underpins the qualitative paradigm and instead argues that constructivism is an ontological stance, that emphasises 'that social phenomena and their meanings are continually being accomplished by social actors' (Bryman 2008: 19).

Tashakkori and Teddlie state that there have been many debates regarding the compatibility of quantitative and qualitative methods, as the underlying paradigms of each were incompatible and therefore impossible to unite (Tashakkori and Teddlie 1998). Sometimes called the *paradigm wars*, the debate was mainly concerned with 'either-or thinking' (Punch 2005: 2). Some researchers argued that studying human behaviour should be restricted to quantitative approaches, whilst others emphatically argued the opposite, with qualitative methods being seen as the most appropriate (Punch 2005).

In his debate regarding the effects of combining qualitative and quantitative methods into mixed methods, Morgan looked at the claim that knowledge produced by the various research paradigms is incommensurable, stating that the metaphysical paradigm 'took a strong stance with regard to incommensurability' (2007: 62), in that if one paradigm was accepted, all other paradigms had to be rejected, while at the same time, communicating knowledge between paradigms proved impossible (Morgan 2007). However, he goes on to agree with Kuhn's rejection, in his 1969 postscript, of that argument, with Kuhn suggesting that scientists of differing paradigms share many similarities from the stimulus of their everyday activities, to similar upbringings and history. Kuhn suggests that they therefore merely need to learn how to communicate with each other and translate between their two understandings (Kuhn 1996: 201). Morgan goes on to state that incommensurability is only relevant in debates about the nature of truth and reality (Morgan 2007: 64).

Despite the arguments of the two camps discussed above, in 1959, Campbell and Fiske proposed the use of 'a multitrait-multimethod matrix' (1959: 1), which, whilst still focusing on quantitative methods, suggested using various methods of inquiry. This idea of using multiple methods has developed over the years into mixed methods or multi-strategy research.

As the aim and research questions were interdisciplinary, crossing boundaries of disciplines, from scientific aspects of climate change to the sociological aspects of behaviour change, to agricultural extension and psychology, it therefore seemed appropriate to use both quantitative and qualitative methods. As a result, a mixed methods approach to the research was chosen as it allowed exploration of both quantitative and qualitative results. There are a number of paradigms that justify the use of mixed methods research such as the critical realist, the transformative, and the pragmatic paradigm (Morgan 2007). Tashakkori and Teddlie describe this latter paradigm stating: 'pragmatists consider the research question to be more important than either the method they use or the worldview that is supposed to underlie the method' (1998: 21). These different mixed methods paradigms are discussed below before stating the viewpoint of this thesis.

4.3.3 Methodological viewpoint.

Incorporating both quantitative and qualitative methods either sequentially, concurrently or transformatively (using a theoretical lens) to reinforce each other, or triangulate data (Creswell 2009), mixed methods research (MMR) is often associated with a pragmatic paradigm. Tashakkori and Teddlie define mixed model studies as studies which combine qualitative and quantitative approaches at different points of the research, and are produced from the pragmatist paradigm (1998: 19). Cherryholmes states: 'For pragmatists, values and visions of human action and interaction precede a search for descriptions, theories, explanations, and narratives. Pragmatic research is driven by anticipated consequences' (1992: 13). Tashakkori and Teddlie describe the epistemology as a viewpoint both objectively and subjectively, with the ontology as 'Accept external reality. Choose explanations that best produce desired outcomes' (1998: 23). Morgan describes the pragmatic method as relying on reasoning of an abductive nature, moving between induction and deduction, from creating theories from observation, to evaluating those theories using various methods. He goes on to call Tashakkori and Teddlie's view of pragmatic epistemology above as 'intersubjectivity' to capture the duality of objectivity and subjectivity.

Morgan finally addresses the qualitative focus on knowledge that is contextual and specific, and the quantitative focus on knowledge that is more general or universal. He uses the term transferability for the pragmatic approach, sharing and exchanging knowledge in different circumstances (Morgan 2007). Johnson and Onwuegbuzie translate pragmatism in mixed methods research as; answer your research questions using the best and most suitable mix or combination of procedures and methods for answering the question (2004). This suits an interdisciplinary study that explores areas of both science and social science, with understanding and knowledge of climate change and agriculture interlinking with sustainable livelihoods and agroecology, yet not remaining static. Instead, the knowledge and belief of those topics is allowed to continue to question, explore and change as new knowledge emerges (Plowright 2011).

Mertens, however, proposes that mixed methods can be associated with a transformative-emancipatory paradigm (2003). Viewed as the 'socio-political commitments domain of MMR' (Teddlie and Tashakkori 2010: 4) and leaning more towards a mixture of participatory methods, it focuses on social justice, human rights and power and often involves the participants in the whole research design (Mertens 2007, 2010). Mertens expands her writing that the transformative paradigm has two key foci, the first on the conflict which occurs when unfair and unjust relationships of power surround the exploration of apparently intractable problems of society; the second on communities' strength and empowerment when their rights are honoured and valued (2009). The transformative paradigm also tries to understand the dynamics of privilege and power, and see how, they can be contested. This sits alongside focusing on the most appropriate strategies for a culture to facilitate knowledge that will create sustainable change for society (Mertens 2009). The transformative paradigm includes an individual's worldview and his/her implicit important assumptions that knowledge is subject to human interests and therefore not neutral. Power and society's social relationships are reflected in knowledge, and through constructing knowledge, people can be aided to improve society (Creswell and Plano

Clark 2011). Mertens et al. discuss how using mixed methods under the transformative paradigm, and engaging with marginalised communities, allows for significant contextual aspects such as human rights, power, oppression, and justice to be tackled. This is because the different types of questions asked, designs used, approach for the design usage, and the nature of the information that can be collected can correctly represent and benefit the cultural communities (2010).

The critical realism paradigm, discussed by Bryman has similar understandings, in that by introducing changes, critical realism offers the prospect of transforming the status quo (2008). Realists search to identify what has potential and is necessary and possible in the world, what might happen, what goes together, even the nature of objects (Sayer 2000). 'Critical realism offers a rationale for a critical social science, one that is critical of the social practices it studies as well as of other theories' (Sayer 2000: 11, 18). Creswell and Plano Clark summarise Maxwell and Mittapalli's chapter on critical realism in the *Sage Handbook of Mixed Methods in Social and Behavioural Research* (Maxwell and Mittapalli 2010) as a philosophical outlook, which supports and corroborates the significant features of both qualitative and quantitative approaches. They go on to state that the authors' discussion of 'critical realism as an integration of a realist ontology (there is a real world that exists independently of our perceptions, theories and constructions) with a constructivist epistemology (our understanding of this world is inevitably a construction from our own perspectives and standpoint)' (Creswell and Plano Clark 2011: 44–45). Maxwell and Mittapalli add that realism has significant implications for approaches which push both the quantitative and qualitative researchers to investigate issues closely which previously they may have ignored or dismissed (2010). Roy Bhaskar, who originated the philosophy of critical realism, has more recently been looking at the relevance of using the philosophy of critical realism and interdisciplinary advances to respond to climate change intellectually. 'Strong arguments are presented to show that critical realist approaches, or something very close to them, will be an indispensable part of an adequate intellectual response to climate change and the multitude of linked phenomena with which we have to deal in the twenty-first century' (Bhaskar and Parker 2010: vii). This may be important when reviewing climate change and its impact on farming[61].

Dialectics is, as Greene describes, 'a mixed methods way of thinking' (2007: 20) or an orientation and attitude towards research and evaluation of a social nature which is 'rooted in a multiplistic mental model and that actively invites to participate in dialogue' (Greene 2007: 20). Greene argues that using multiple ways of hearing, seeing, making meaning from the social world, as well as considering a range of standpoints on what to value, cherish and acknowledge, is important (Greene 2007). Thinking dialectically involves taking into account interacting with juxtaposed of opposing viewpoints and the tension that they cause. The tensions arise from differences in inference of the various paradigms (Teddlie and Tashakkori 2009). The goal is to deepen the understanding gained, rather than just triangulate or broaden, through the creation of a dialogue between the various points of view on the phenomena being examined (Maxwell and Mittapalli 2010). The dialectic stance encourages the bringing together of differing mental models and multiple paradigmatic traditions, multiple methodologies, and various methods into one respectful discussion with each other, in the same space, throughout the research inquiry (Greene and Hall 2010).

A search of studies using mixed methods in the disciplines of climate change, agriculture and agroecology reveal a small number of articles that specifically discuss using mixed methods (Lorenzoni et al. 2007, Kristensen and Enevoldsen 2008, Farmer et al. 2011, Nyanga 2012, Capstick and Pidgeon 2014, Santiago-Brown et al. 2015). However, none of them explore their methodological viewpoint, merely stating if they were derived from a pragmatic, transformative, critical realism or dialectic standpoint. Furthermore, Bamberger et al. explain that in international development, whilst the mixing of both quantitative and qualitative methods has been used for many years, it

[61] However, given the current uncertain political situation in the USA around climate change, this may no longer be the case.

was without the theoretical and methodological rigour required by the *Journal of Mixed Methods Research (JMMR)* (Bamberger et al. 2010). Looking back at the articles listed above, only one was published in *JMMR* (Santiago-Brown et al. 2015) whilst the remaining five were published in journals relating to the topic of their article (climate change, dairy farming, conservation agriculture), with mixed methods merely being the tool to collect the data. Whether this was because applications were made to JMMR and they did not succeed is not apparent. Yet, the authors clearly felt that the tool was significant in their research as they specifically mentioned it in their abstracts or titles of their articles.

However, for the sake of this thesis as a submission to a doctorate of philosophy award, in addition to using the tool of mixed methods, of the different viewpoints (pragmatic, transformative, critical realism and dialectic), the pragmatic approach was applied to the research. There is the acknowledgment of Bhaskar et al.'s view that critical realism is important in responding to climate change (Bhaskar et al. 2010); however pragmatism accepts the values of humanity and would assume that evolving and changing viewpoints and beliefs of farmers is common. Furthermore, given one research question explores barriers to changing behaviour towards agroecology and sustainable agriculture, pragmatism was appropriate.

Having discussed the methodology, philosophy and worldview behind the research, the chapter now examines the design of the research before moving on to considering specifically the two data collection phases.

4.4 Research design

This section considers first (4.4.1) at an analysis of stakeholders' which might influence the data collection. It then (in 4.4.2) introduces the research objectives to provide the measures to meet the research questions, before looking at the methods and analysis used in the throughout this research (Section 4.4.4).

4.4.1 Assessment and analysis of potential stakeholders

After reviewing the literature, but before beginning the data collection, an assessment and analysis of any stakeholders in the UK was conducted to help inform which stakeholders might have interest in taking part in the research and thus help direct the publicising of the Phase 1 and Phase 2 data collections. It included those who had interests in, influences on, or were affected by climatic impacts on farming and any environmental concerns. The literature in Chapter 2 was explored to determine primary stakeholders (those with a direct interest in farming), secondary stakeholders (those who provide advice and potentially influence), and external stakeholders (who might have some direct influence on farmers, but more influence on the entire agriculture sector). The Table A2 showing the stakeholder analysis is in Appendix 2.

Not all of these stakeholders identified were included in the data collection, (due to the self-selecting nature of the respondents to the two phases of data collection); only people from the primary and secondary sections of Table A2 were surveyed and interviewed, this is discussed more in 4.5 below. The table also considered female farmers, given that whilst looking at the agricultural census data and farm business survey literature, it would appear that Wilson et. al (2011) stated that only 5% of those completing the farm business survey were women. After considering the respondents of the survey and interviews, the table was revised and looking more recently, DEFRA and the National Statistics (2015) assessed that in 2013 only 16% of females owned their farms and only 17% were managers.

4.4.2 Research objectives

The objectives stated here provide the measures that are needed to meet the research questions listed above. As a result, there are similarities between the two which are shown in Table 4-2 on pages 143-144 below.

1) Critically review literature to assess current knowledge of drivers and barriers to behaviour change for farming agroecologically and the implications of climate-resilient farming for the broader food system.
2) Using themes drawn from reviewed literature, explore the current drivers and barriers to agroecological change of UK farmers, along with interventions for climate-resilient farming that ensure sustainable livelihoods for UK farmers.
3) Critically evaluate, using the livelihoods analytical framework in Figure 3-1, the Phase 1, Phase 2 and then the full primary data collected to assess barriers and drivers of mitigating against climate change, alongside agroecological interventions for climate-resilient farming.
4) Assess the implications of agroecological change for the broader UK food system revealed from analysis of the literature and data.

4.4.3 Methods and analysis

The research first began with a review of literature which explored the context, current practices and theories around climate change, agriculture, agroecology, and behaviour to help shape the design of the primary research. In utilising an interdisciplinary approach to this thesis by looking at both climate change and farming along with the social aspects, neither the traditional approach of quantitative or qualitative methodologies were applicable by themselves. From the pragmatic paradigm, using an explanatory design of mixed methods sequentially in two phases of primary data collection, allowed for the results from an initial (mainly quantitative) data collection to develop and build the qualitative part of the research (Creswell and Plano Clark 2011). It also allows the data to be triangulated, correlated and compared. Within the methods, the questions were mixed between quantitative and qualitative as well as the two different methods (surveys and interviews) (Teddlie and Tashakkori 2009).

> 'The data analysis procedures in the explanatory design involve first collecting quantitative data, analysing the data, and using the results to inform the follow-up qualitative data collection' (Creswell and Plano Clark 2011: 221).

Following the review of the literature prior to data collection, the first phase of mainly quantitative research (see 4.5.2 below) was carried out using primarily Internet-mediated research (IMR)[62], which is the use of the Internet to gather primary, original data (Hine 2010). This brought new ethical issues, so ethical approval from the university Ethics Board for medium-high risk research was submitted and approved (see Appendix 3). In addition, because by using IMR for survey data collection, there is no direct contact with the participants of the research, it was important to implement suitable procedures to obtain informed consent and to debrief the participants (Hine 2010). As a result, consent forms and a participant information sheet were inserted into the online quantitative research (see Appendix 4-5 for relevant documentation).

The second phase of mainly qualitative research (see 4.5.3 below) was carried out using one-to-one interviews with both participants of the Phase 1 survey, and those who had attended workshops from one of the agroecological interventions (RegenAG UK), along with two group interviews. This was undertaken in a similar style to focus groups (Bryman 2008), narrowing down to focus on just the one agroecological intervention, RegenAG UK. As Phase 2 was different from the survey, ethical approval was once again sought, once the questions were finalised. It also fell under the medium – high risk category at Coventry University, so all the appropriate documentation was also included and is shown in Appendix 3 for the ethical approval and Appendices 6-7 for participant information, consent form and interview questions. As most of this additional documentation was an adaption of the survey documentation, such as the participant information sheet, those elements therefore did not require too many changes. This also necessitated suitable procedures for the storage of the recordings, transcripts and photos from the interviews (individual and group). These were secured on Coventry University's individual student secure storage sites, with a backup stored on a secure hard drive.

[62] Whilst the first phase of primary data collection used an online survey, it also was printed off and sent out as a paper version when required. As a result, it was primarily IMR with one completed via a posted paper survey.

Looking at the research questions separately, with their related objectives, various methods appeared to be more suitable than others. The first and second questions required initially a critical review of peer reviewed, international and UK governmental and non-governmental organisations' literature (see Chapter 2). As stated at the beginning of this chapter, they were:
What are the characteristics of agroecological interventions for building climate-resilient farming communities and ensuring sustainable livelihoods for UK farmers? and *What are the drivers and barriers to behaviour change in farmers towards using more agroecological practices to build climate-resilient farming communities?*

The review assessed successful agroecological and sustainable agricultural interventions and the current knowledge available in the above types of literature of the different drivers and barriers to sustainable behaviour change in farming. The third research question was also assessed in the literature review: *What are the implications of such changes for the UK food system?*

Using concepts drawn from reviewed literature, the research questions were then investigated and analysed using first a survey (Phase 1) and then interviews (individual and group) (Phase 2) to assess the current drivers and barriers to change of the responding farmers, along with their views on successful and unsuccessful attempts to farm agroecologically and any implications for the UK food system. The results of the analysis of Phase 1, Phase 2 and a joint analysis can be found in Chapters 5-7.

In addition to the analysis of the data, the validity of the quantitative, qualitative and mixed results, data and interpretation was checked. In mixed methods, this validation has various names. Onwuegbuzie and Johnson call it 'legitimation' (Onwuegbuzie and Johnson 2006) whilst Teddlie and Tashakkori call 'inference quality' as an overarching term between trustworthiness and internal validity (Teddlie and Tashakkori 2009).

They employ the term inference as the term for the outcome of the data and its analysis in constructing meaning (Teddlie and Tashakkori 2010). Creswell and Plano Clark sum it up as utilising strategies to deal with any issues that might occur during the collection, analysis and interpretations of the data, which might undermine the mixed analysis and conclusions drawn from that combined analysis (Creswell and Plano Clark 2011). They suggest a variety of strategies to avoid validity risks, which the author took into account when beginning the data collection. These included using the same sample of participants in the Phase 1 survey for both qualitative and the quantitative questions, addressing the same topics in both qualitative and quantitative data collection and finding quotes to match the quantitative statistics (Creswell and Plano Clark 2011).

Following the individual analysis of each phase, (from first the survey and then the interviews), the full data was then analysed together to assess barriers and drivers of change and if there had been any successful interventions. Mixed data analysis was also applied to the data to determine connections between the quantitative and qualitative data (Teddlie and Tashakkori 2009).

At the end of the research, the acquired data answered the research questions and provided case studies of successful techniques for interested farmers (as shown in Chapter 8). This could lead to further work creating a move across the UK farming industry towards more sustainable, agroecological, climate-resilient farming.

Table 4-1 below, shows where the aim and research questions are addressed by the research methods, and in which chapters they are all addressed, whilst Table 4-2 below, shows which objectives relate to the aim and research questions.

Table 4-1: How the aim and research questions meet the research methods, along with the relevant chapters where they are addressed.

Methods	Aim	Research Question 1	Research Question 2	Research Question 3
	To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities and livelihoods.	What are the characteristics of agroecological interventions for building climate-resilient farming communities and ensuring sustainable livelihoods for UK farmers?	What are the drivers and barriers to behaviour change in farmers towards using more agroecological practices to build climate-resilient farming communities?	What are the implications of such changes for the UK food system?
Secondary Literature	Chapters 1-3, 7	Chapters 1-4	Chapters 1-2, 4, 7-8	Chapters 1, 4, 7, 8
Survey	Chapters 4-5, 7-8	Chapter 4-8	Chapter 4-8	Chapter 4-8
Semi-structured individual interviews	Chapters 4, 6-8	Chapter 4, 6-8	Chapter 4, 5-8	Chapter 4, 7-8
Semi-structured group interviews	Chapters 4, 6-8	Chapter 4, 6-8	Chapter 4, 5-8	Chapter 4, 7-8

Table 4-2: Showing how the objectives meet the aim and research questions.

Objective 1 - Critically review literature to assess current knowledge of drivers and barriers to behaviour change for farming agroecologically and the implications of climate-resilient farming for the broader food system.	**Aim -** To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities		**RQ2 -** What are the drivers and barriers to behaviour change in farmers towards using more agroecological practices to build climate-	

			resilient farming communities?	
Objective 2 - Using themes drawn from reviewed literature, explore the current drivers and barriers to agroecological change of UK farmers, along with interventions for climate-resilient farming that ensure sustainable livelihoods for UK farmers.	**Aim -** To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities	**RQ1 -** What are the characteristics of agroecological interventions for building climate-resilient farming communities and ensuring sustainable livelihoods for UK farmers?	**RQ2 -** What are the drivers and barriers to behaviour change in farmers towards using more agroecological practices to build climate-resilient farming communities?	
Objective 3 - Critically evaluate, using the livelihoods analytical framework in Figure 3-1, the individual Phase 1 results, individual Phase 2 results and then the full data collected to assess barriers and drivers of mitigating against climate change, alongside agroecological interventions for climate-resilient farming.	**Aim -** To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities	**RQ1 -** What are the characteristics of agroecological interventions for building climate-resilient farming communities and ensuring sustainable livelihoods for UK farmers?	**RQ2 -** What are the drivers and barriers to behaviour change in farmers towards using more agroecological practices to build climate-resilient farming communities?	
Objective 4 - Assess the implications of agroecological change for the broader UK food system revealed from analysis of the literature and data.	**Aim -** To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities			**RQ3 -** What are the implications of such changes for the UK food system?

4.5 Description of implementation of the two phases of data collection

The two phases of data collection were split between Phase 1 as a survey, and Phase 2 as individual and group interviews.

The Phase 1 data was collected through a survey of both quantitative and qualitative questions about farming in the UK, sustainable farming and behaviour change, along with views on impacts on farming from a changing climate, production systems for the broader food system and successful agroecological techniques the respondents had used. A survey was chosen because it gave the opportunity to gather a wide range of people's opinions and views, creating a more general selection of data, with fewer specifics, and unless they chose otherwise, would allow anonymity, which might be a benefit for some farmers (Robson 2011). As there might have been the issue that participants may not have understand the question and did not have the opportunity to ask for clarification those issues were addressed partly through highlighting any confusing or ambiguous questions during the pilot and adapting them to be clear to participants before the full survey was distributed.

The survey was initially sent out as a pilot study to ten farmers from a mainly organic background who were connected to Garden Organic. They were chosen for their accessibility as an opportunity sample to gain initial data on the survey. It was then adapted as necessary. From analysing those who would be interested from Table A2, participants for the full survey were recruited by email, post, the Internet and Twitter to get a sample of both conventional and those more agroecological, such as organic, permaculture or holistic farmers who might have an interest in AaSF. The survey included questions of both a quantitative and qualitative nature, with the aim of getting 50-100 farmers, with a broad sweep of farmers from across different farming sectors to complete the survey either online or by mail. Whilst the creation of the continuum in Figure 2-1 was retrospectively created after data collected and analysed, there was the plan that through publicising the survey via different methods of communication farmers might be encouraged to complete the survey from across conventional, organic or even more climate-resilient farming sectors.

Phase 2 involved interviewing individually using semi-structured interviews and in small groups, (in addition to those who had taken part in Phase 1 and were interested in continuing in the research) those who had taken part in a RegenAG UK training course. Ideally, some of the farmers would be those taking part in other interventions such as organic farming, or permaculture, plus those who had used one of the many carbon calculators available such as the Cool Farm Tool.

The initial questions were developed from the Phase 1 survey responses, and then adapted as each interview was undertaken. There was the aim of getting 20 farmers or advisors to respond for about an hour-long interview each. The group interviews were designed to have two groups of about 6-8 people in each, with the first exploring how RegenAG could embed within the farming community in the UK, and the second looking at major issues such as climate change, and how RegenAG could address them, encouraging climate-resilient farming. This figure was based on previous experience of group dynamics and the ideal number to encourage sharing and exchanging of information, working alongside the number of people who indicated they would come to the workshop.

4.5.1 Farming context of contemporary agricultural, socio-political, economic and environmental issues that occurred during the data collections

This section is included in Chapter 4 rather than the review of literature in Chapter 2 as it is specifically regarding issues which might influence the answers of respondents during the data collection (rather than the context and theories which relate to the wider issues of climate change and agriculture and their impacts on each other).
With regard to the Phase 1 survey, the webpages for Farmers Weekly (Farmers Weekly 2016b), National Farmers' Union (National Farmers Union 2014b), Soil Association's Farmers and Growers page (Soil Association 2014b), DEFRA (DEFRA 2014) and

AgriChat's discussions (AgriChatUK 2014b), showed that the winter-spring 2013-14 period was dominated by the weather. Flooding in particular led the news, which impacted on crops and animals in the South-West as well as destroying machinery left behind, where farmers only had time to move their stock (National Farmers Union 2014a). Given the survey was open over December and January 2013-14; the weather may have influenced any farmers who completed it, since it coincided with the flooding. However, analysis in Chapter 5.2.1 will discuss this further.

Other frequent topics which were observed in the online farming literature during the Phase 1 data collection included the CAP reform, both within the UK (Farmers Weekly 2016b, NFU Online 2014) and on the European Union website (European Commission 2014b). The CAP reform was looking to amend the monetary provision and attached regulations, which support farmers and the farming industry in European countries (NFU Online 2014).
At the latter end of the data collection of Phase 2, there was once again flooding (DEFRA 2015e), but this was only a minor topic in the interview discussions. Unlike the Phase 1 participants, all the interview respondents believed in climate change, and two had degrees in ecology.

Other issues included both in the news and during the Phase 2 individual and group interview discussions were the change in government departmental budgets and reduction in energy feed-in tariffs (Howard 2015, Spackman 2015b); the Paris climate change agreement (National Farmers Union 2015c); neonicotinoid ban (Tasker 2015), EU referendum (Helm and Zeffman 2015); and antibiotic resistance (Gallagher 2015). 2015 was also the FAO International year of the soils (FAO 2015e) and much of the interview discussions focused on soil and improving the soil.

4.5.2 Phase 1- survey

The survey was developed from the pilot, the results of which (along with the logical development of the full survey questions) are discussed below. Following that, this section then explores what happened in practice, from the publicising of the survey to the analysis. Gender was not asked as a specific question for the survey due to the fact that it was not obviously relevant to the aim and research questions.

How survey was developed from pilot

As discussed earlier, the pilot survey was an opportunity survey sent out to ten farmers from a mainly organic background (two respondents were conventional farmers in Wales) who were connected to colleagues from Coventry University who were linked with Garden Organic. Both the pilot survey and the full survey were created working from the aim and research questions which had been developed following an initial literature review in 2011-12 (see Appendix 1). Furthermore, the questions regarding environmental schemes were also formed from the initial literature review[63]. In hindsight, it is evident that literature regarding surveys was not read in detail, and statistical workshops were not attended until after the pilot survey was already completed. As a result, things did not proceed in the more traditional order. This meant that a hypothesis was not consciously created first or the questions drafted intentionally with the aim of being able to successfully analyse both statistically and qualitatively.

Additionally, whilst the information gathered from the pilot survey was useful in developing the question topics for the full survey, the comments received from the Phase 1 survey completion post on The Farming Forum (TFF) were more valuable with regards to minor technical problems with the online survey, and had the survey been piloted on that forum it may have been more beneficial during the creation of the full Phase 1 survey than the organic farmers group that was used[64].

Gillham reassures that research does not always occur in the most logical order and that ‘those who assert that it does only have experience of research methods from

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[63] Where relevant and still ongoing, environmental schemes and interventions are included in Chapter 2, however, the remainder can be found in the latter half of Appendix 1.
[64] This is discussed further below in the section titled *Survey – what actually happened.*

textbooks’ (Gillham 2007: 15). He also states that whilst one might not create a stated hypothesis, ‘researchers commonly have ideas they are testing out or checking on when they construct a questionnaire’ (Gillham 2007: 8). Certainly, checking about the barriers and opportunities that might influence farmers to change towards more agro-environmental agriculture was felt to be important at the beginning of this research. These included questions in the analysis of the data such as *are farmers who have a bigger income more likely to install photovoltaics?* Alternatively, *would livestock farmers know or even care about minimum tillage if they do not grow any crops?*

Logical development of survey questions

The survey (which can be read in Appendix 5) was designed to meet all three of the research questions listed in 4.2.2.

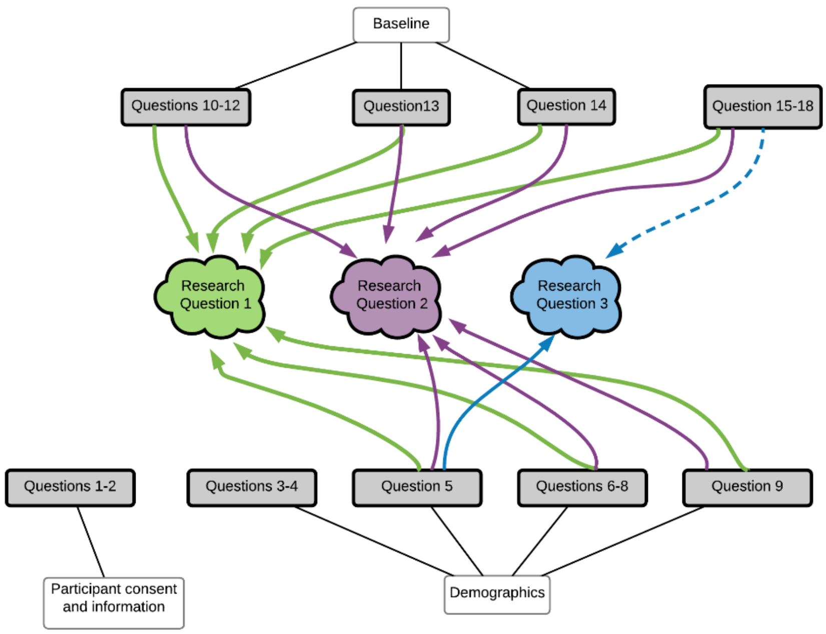

Figure 4-1 showing questions and their relation to the research questions

As shown in the Figure 4-1 above, the first two questions are participant consent questions, whilst the remaining early questions (3-9) ‘about you and your farm’ are mainly demographic questions to help with survey analysis, such as Are arable farmers more likely to notice water shortages? Or, Are farmers with more land, or more income likely to change their farming methods to more agro-environmental techniques?

Question 9 asks if the participant is in an environmental rated scheme (the list of schemes was developed from the initial literature review section on existing interventions now in Appendix 1 except where shown in Chapter 2) and was designed to help answer research questions 1 and 2. Additionally, question 5 on farm sectors was relevant when assessing all three research questions.

Operationalising and publicising the survey

Once the survey questions were finalised and ethical permission was granted (see Appendices 3-5), the survey was created on Bristol Online Survey (BOS 2015) and launched. A web link was provided to use for publicising the survey.

The sample was an opportunity snowball sample, in that it was open to as many farmers as possible so there was the best probability of farmers from different farming backgrounds completing it. However, due to the self-selecting nature of those who respond to the survey, it was unlikely that there would be a stratification of the population (Creswell 2009). The survey was emailed out (as discussed below) with the web link, but there was also the option to complete the survey through an attached Word file sent by email, or if farmers wished it, sent by post. The opportunity for farmers to get involved further with the research was included as an option for them to select at the end of the survey.

Contacts that had been collected over the last two years were emailed with a request to publicise the survey. These included Farming and Countryside Education (FACE 2014), NFU (National Farmers Union 2014b), Soil Association (Soil Association 2014b), Farming Futures (Farming Futures 2013), Food Climate Research Network (FCRN 2013) and the rural chaplains for Oxfordshire (The Diocese of Oxford 2013) and Herefordshire (The Diocese of Hereford 2014).

Two email contacts very helpfully sent on the survey to other people and one even offered ways to improve publicising by Twitter (removing some of the privacy restrictions on the Twitter account, adding a brief description to the Twitter profile and sending tweets directly to people who were not following the tweets, but could publicise the survey). As a result, the survey was further publicised via sending direct messages on Twitter to farmers who were following the account along with tweeting the survey (see Figure 4-2) using specific hashtags which are used for discussions once a week such as #AgriChatUK (AgriChatUK 2014a) or #clubhectare (Twitter 2014).

Figure 4-2 Tweet to gain survey participants (Hartless Rose 2013)

This slowly began to collect more responses and opened up new opportunities for publicising the survey such as using TFF (The Farming Forum 2014) which is popular discussion forum amongst the farming community in the UK.

Survey - what actually happened?

By the time the survey closed, 43 farmers responded. However, this was after two revisions due to unintended mandatory questions on the survey.

A high response rate of 40% would have been beneficial to allow further statistical analysis; however, previous experience of online surveys suggested that this was not that realistic, despite offering to feedback the results to the respondents so they could learn from the experience of their peers. As a result, a response rate of about 20% was actually expected. 22% of the 195 respondents who clicked the web link publicised went on to complete the survey. This was a small increase on the expected response rate.

Originally, the survey was planned to close in early December, but by the 10th November 2013, there were only 10 respondents. As a result, after advice from the supervision team over how valid the data would be if the questions were changed, it was felt that simply switching questions from being mandatory to optional would not influence too severely on the data and therefore might be beneficial. As a result, after editing the mandatory questions on the survey it was reopened until mid-January 2014. However, shortly after Christmas, a further comment was received that question 16 on agroecological farming techniques also mistakenly had a mandatory answer for the part of the grid with a 'if not why not' question, creating confusion with those who had answered the original question with a 'yes they used the technique'. The survey was once again edited and reopened on 30th December 2013 with that question corrected.

Ideally, these errors should have been picked up during the testing of the survey, but whilst some questions had been tested, a test had not been conducted for every possible response. Were data collection to be repeated, every response would need to be tested. In hindsight, it would also have been far more useful to pilot the survey using TFF (The Farming Forum 2014) as they were far more responsive and communicative about the validity of the questions than the ten participants who were used for the pilot (who did not comment overly about the questions) .

Phase 1 analysis

Following the collection of survey data, it was coded and analysed using parallel mixed data analysis in a combination of statistical software SPSS and a qualitative analysis tool NVIVO to draw out key topics, concepts and themes[65] to investigate further with the second stage of research. The quantitative data collected was categorical (otherwise known as nominal) data and therefore was analysed using descriptive statistics and where possible non-parametric statistics within SPSS. For the former,

[65] Whilst NVIVO calls these nodes (LEAF 2017), for the sake of this thesis they are called codes throughout the remainder of this and Chapters 5-7.

frequencies of responses or the percentages were stated or presented in graphical format (Pallant 2016). For the latter, as the sample was small with expected frequencies of less than 5, using Pearson's chi-square test to assess the relationship between two categorical variables (or items of data) was not suitable; the statistical significance tests of the chi-square distribution become inaccurate (Field 2013).
As a result, Fisher's exact test was chosen as it calculates the chi-square distribution of small samples to assess 'whether the proportions of one variable are different depending on the value of the other variable' (McDonald 2014: 77). A simple example to assess if there is any relationship between farmers who were or were not beef farmers, against whether or not they were using grazing management is shown below in Table 4-3.

Table 4-3 Showing example showing the variables assessed using of Fisher's Exact 2x2 test for significance.

Beef farmer using grazing management	Beef farmer not using grazing management
Not beef farmer but using grazing management	Not beef farmer, not using grazing management

Concepts drawn from the initial literature review (see Appendix 1) and Chapter 2, which were used to create the questions for the survey, were then vital in informing the interview questions for Phase 2. This included question 9 regarding agricultural schemes which the participant was part of (drawn from 2.5, and A1.2 in Appendix 1), and questions 15 and 16 on whether the participant had used certain agricultural techniques to mitigate against climate change (which were drawn from 2.2.4 and 2.3.2 in Chapter 2, such as renewable energy, grazing management and minimum tillage). In addition, by asking for examples of successful agroecological or sustainable farming techniques from the survey participants, they were invited to respond using descriptive responses. However, it was important to avoid making assumptions about the responses and let the codes form from those responses. Further analysis of the Phase 1 data collection is in the next chapter.

4.5.3 Phase 2 – interviews (individual and group)

All three of the previously mentioned research questions were investigated further through the second stage of research design, which narrowed down from the general data of the survey, to more specific questions and data collection so that for any confusion over questions could be addressed directly between the interviewee and interviewer.

Developing the questions

Based on the results of the survey and how closely they met the research questions, a series of initial questions were developed that would be asked during the individual interviews. Some of those questions were also asked during the group interviews. The questions were a mix of closed and open questions, using initial concepts drawn from the literature and the surveys. Time was allotted for other questions to develop from answers as well as answering any queries the participant may have. As the interviews were open ended, the questions were just a starting point and more questions were introduced during the current interview conversation and from previous interviews. A final list of questions is shown in the Appendix 7 at the back.

Recruiting the interview participants.

Farmers who had shown an interest in getting further involved after completing the Phase 1 survey were contacted to see if they wished to continue to take part. Of these participants, seven of the survey participants got back in touch, agreeing to be interviewed. They were interviewed along with participants who have taken part in one of the *Regenerative Agriculture UK* (RegenAG UK) training courses (RegenAG UK 2013) with fifteen interviewed individually in total. The combination of participants of the survey and the RegenAG UK training courses who were happy to be interviewed, were discovered to have formed a continuum of farms from those that were using agroecological techniques, to those that had tried and had difficulties, to those who were farming using very few sustainable methods. They also included interviews with farmers who had taken part in successful interventions for more in depth understanding. Farmers who were members of RegenAG UK were invited to a workshop before the Oxford Real Farming Conference 2016 where the group interviews were planned to run throughout. There were two group interviews, one with fourteen people in it, whilst the other had six people in it.

Interviews (individual and group)

The interviews took place at a time suitable to the participant, via telephone or online video calling and in a few cases, face-to-face. Due to ill health, the telephone interviews enabled data collection to continue despite the researcher's inability to travel far. Some farmers had to delay their interviews due to weather, so the interview period extended for six months. The interviews took place individually per farm. The interviews were recorded and transcribed, and the data was coded and analysed using the software NVIVO.

Figure 4-3 SWOT analysis of ways to embed RegenAG UK in the UK farming scene

Both group interviews used participatory methods using Ketso kits which are designed to encourage creativity and engagement (Ketso 2016) among the group interview participants. This involved giving everyone in the group laminated leaves and a pen and encouraging them to write on the leaves, and getting the group to agree where to position the leaves on a felt (Ketso 2016). They were also encouraged to group them into branches for themes, and photos were taken of the results (see Figure 4-3 above).

The first group (of fourteen people) considered the ways to embed RegenAG UK in the UK farming scene using a SWOT analysis[66]. This group was also recorded using a Dictaphone, but the second group (which was not so relevant to this thesis research) found the recording did not work due to faulty equipment. Furthermore, due to the lack of a facilitator for the second group, the results were confused and fragmented and therefore this group's data was unusable with no analysis done of their results.

For the group interviews, it was important to recruit a note taker as Robson comments that note taking and recording alongside facilitating focus groups is problematic (Robson 2011). The notetaking was undertaken by this thesis's researcher; however, the second group was not recorded through note taking. The facilitator of the first group encouraged those less articulate to share, and to avoid conflict (Bryman 2008).

Transcription and Phase 2 analysis

As qualitative analysis of the Phase 2 results were occurring alongside each interview, codes were already in place at the time of transcribing the interviews (which were transcribed using dictation software); however further codes were added over the course of the transcriptions and whilst analysing the data afterwards. NVIVO was used to manage the data and coding. Whilst the group interview was recorded, transcription of this was not feasible due to overlapping conversations throughout.

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[66] The leaf colours relate to: Strengths (brown leaves), Weaknesses (green leaves), Opportunities (grey/blue leaves) and Threats (yellow leaves), relating to opportunities to embed RegenAG in the UK.

Further details of the analysis of Phase 2 are discussed in Chapter 6.

4.5.4 Full analysis of both phases

After analysing Phase 2 individually, the two phases were analysed together using NVIVO and SPSS, and evaluated and discussed using the analytical framework from **Error! Reference source not found.** alongside theories drawn from the literature in Chapter 2. The combined results were then presented, examined and discussed in detail in Chapter 7.

4.6 Summary

This chapter introduced the methodology and data collection for this research. Beginning with the research aim and research questions, the chapter next discussed the concepts behind research methods, considering worldviews (including the worldview for this thesis), paradigms, epistemology and ontology, followed by a reflection on the quantitative, qualitative and mixed methods arguments. Section 4.3 ended by considering the different methodological viewpoints that have emerged with mixed methods and which viewpoint (pragmatism) was most relevant to this data collection.

The chapter moved on to introduce the research design, with a brief explanation of the stakeholder analysis that was undertaken before the data collection. This section then introduced the measures to be used to meet the research questions as research objectives. Section 4.4 finally ended with a detailed explanation of the methods and analysis to be used in this study. Table 4-1 and 4-2 summarised how the aim and research questions met the research methods, in which chapters they were referenced, and which objectives related to which research question.

The last section of this chapter (Section 4.5) examined the implementation of the two phases of data collection, from exploring the context of what occurred at the time of the research, to the development of survey and interview questions, the collection of data and then their transcription, and analysis.

The next chapter (5) presents the results of the Phase 1 data collection, with the Phase 2 data presented in Chapter 6, and the full analysis and discussion of the data in Chapter 7.

Chapter 5 - Phase 1 results

5.1 Introduction

Based on the methodology in Chapter 4, this chapter examines the quantitative[67] and qualitative results from the Phase 1 survey of the fieldwork that took place between September 2013 and April 2014.

Using the analytical framework Figure 3.1 from the beginning of Chapter 3, this chapter first explores the farmer households and their assets (via the demographics of the survey participants). The chapter then moves on to examining the respondents' experience of hazards for example from the weather, or financial hazards, before considering again the farmers' assets with respect to accessing resources. After discussing barriers to the participants accessing the resources or changing behaviour to farm in a climate-resilient fashion[68], the chapter finally explores other themes that emerged from the data.

5.2 Consideration of respondents – their households and their assets

Forty-three farmers completed the survey by the time it closed in April 2014, with a cross-section of farming locations, sectors, farm gross turnover and size. Based on the data the respondents gave (which did not ask specifically for gender), eight of the forty-three were female where the respondents gave their name, although there were seven with no names provided and 2 with initials only, so there were possibly female respondents within those results which were not able to be counted. At 18% of the respondents, this works out a little higher than both the Wilson et al. (2011) article and the DEFRA and National Statistics survey of farm labour (DEFRA and National Statistics 2015). Gender was not asked as a survey question as it was not deemed relevant to

[67] Due to the nature of the data gained from the survey, the quantitative results are reported using descriptive statistics and where applicable, non-parametric, categorical results.
[68] Following the initial literature review (see Appendix 1), the phrases used at the time of the survey were sustainable agriculture and climate-resilient farming, however during the update to the literature review (to create Chapter 2) along with the start of the Phase 2 data collection, the phrase agroecology became more dominant, as is explained in Chapter 2.

the aim and research questions, however given the results of Phase 2, it was useful to comparing the data that was available with the government figures. Where possible the data is compared to the 2014 agricultural census (DEFRA et al. 2015), however the census data does not list farming sectors or regions by agricultural holding instead listing them by farm business income, so the data for those results are not compared.

5.2.1 Location of the respondents' farm households

As shown below, the farmers who completed the survey came from across the whole of the British Isles. Figure 5-1 shows the approximate locations of the participants on a map of the UK, whilst Figure 5-2 shows the number of respondents from each region.

Figure 5-1 Map showing location of the Phase 1 survey participants. Those with purple locations also took part in Phase 2. They were from England (the Midlands and Southern England only).

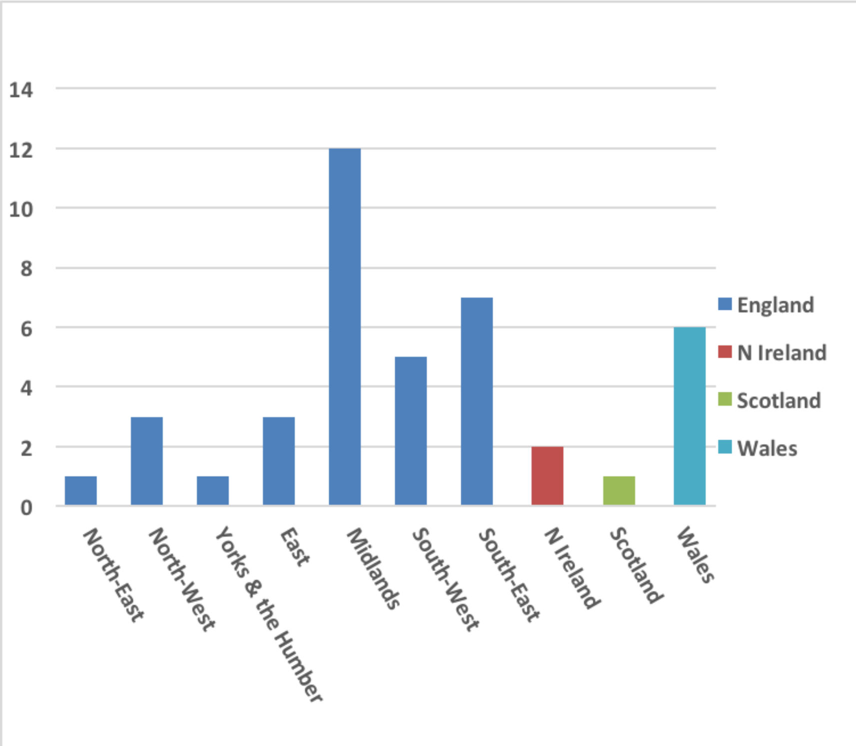

Figure 5-2 Showing regions of Phase 1 survey participants. Two of the 43 did not share their location.

Two farmers did not complete the region question, nor did they leave any other identifying location information. Nevertheless, for the remainder, most farmers completing the survey were from the Midlands, followed by the South-East and then the South-West.

Some of the results may be distorted due to the location. When looking at the date of the respondents, the majority of the farmers in the South-West completed the survey during December-February 2014 when there was severe flooding in that area. This may have influenced their data. However, most of the respondents were from the Midlands, which did not seem to suffer quite as badly as the South-west of England, although it was extraordinarily wet across the whole UK.

As only one respondent was from Scotland and two from Northern Ireland, those results are too small to signify any likely regional indications, however, as part of the UK farming community, their results showed possible themes which were fed into the

Phase 2 data collection. Given the limited cover of respondents in some regions, consideration was given to changing to England, but that would discount the two results from Northern Ireland, six from Wales and one from Scotland, so UK was kept in the thesis title.

5.2.2 Farming sectors

When exploring the results for question 5 (as shown in Figure 5-3 below), it was by chance that respondents were spread across all the farming sectors on the questionnaire, with sheep farming showing the strongest sector across all participants. Some farmers indicated more than one sector which is discussed in the next section.

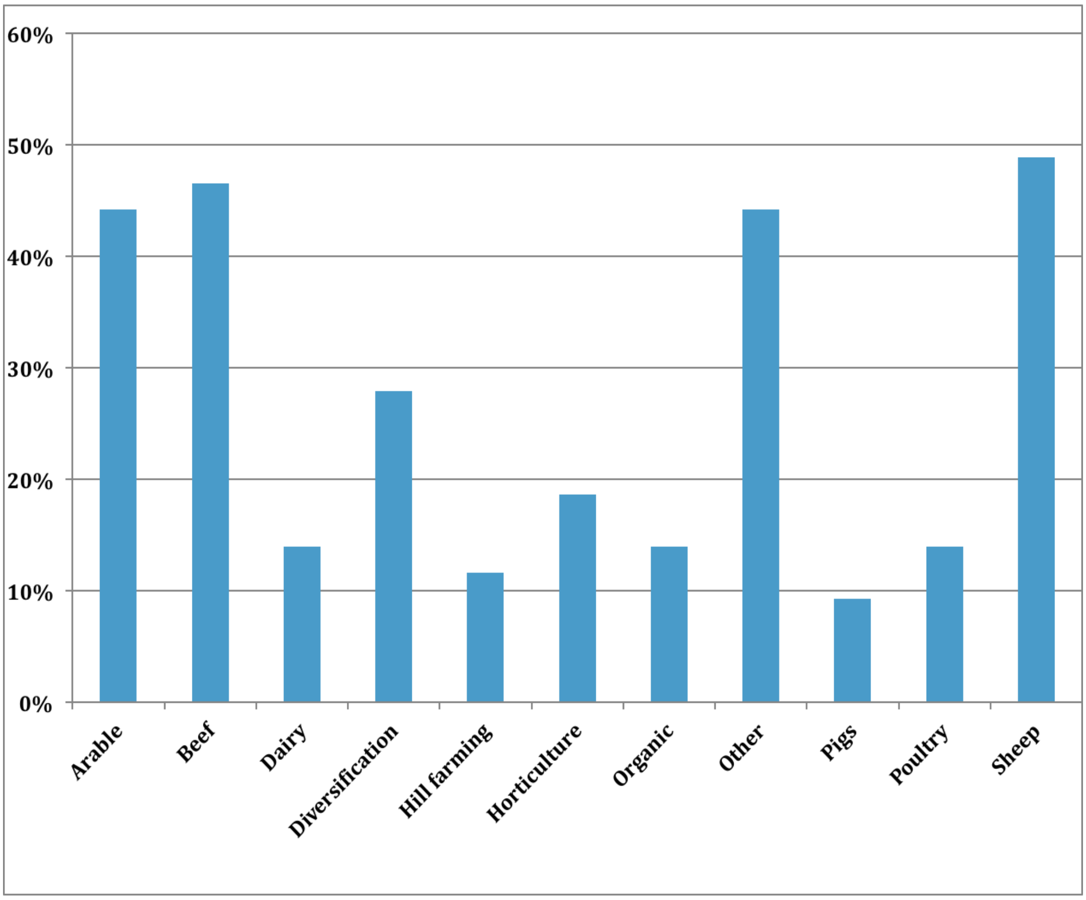

Figure 5-3 Percentage of those participants who indicated on the survey that they farm in specific sectors

Farmer snapshots of individual respondents are shown in *Farm snapshot boxes* throughout this first section of the chapter.

Farmer O farms in Scotland, farming arable, horticulture and sheep. He has also started a glamping business for additional income. His farm is of medium size (40-100 ha) but his gross turnover is in the higher categories (£100k-£500k). He owns 80% of his land, but is not part of any environmental scheme, nor has he calculated his carbon footprint. He struggles with resistance levels of pests, diseases and weeds, but does manage his manure and has a wind turbine for energy production. He feels that minimum tillage, planting deep rooting plants, or maintaining permanent soil cover will not work on his farm. However he has begun to convert the field edges back to hedging and grasslands when financially able. Knowledge is the major constraint for him to farm in a climate-resilient fashion.

Farmer AN farms in the South-West, farming beef, sheep, and pigs along with diversifying to have a farm study centre and wedding venue. His farm falls into the medium size category (40-100 ha) but his gross turnover is in the highest two categories (£100k-£500k) and he owns his land. He is part of one of DEFRA's scheme as well as certified organic farming and the Pasture Fed Livestock Association (PFLA). He calculated his carbon footprint using the climate-resilient food Carbon Toolkit calculator. He has practiced manure and grazing management, and has been using renewable energy and collecting rainwater for many years, whilst 'going for long term perennial pasture crops' for his livestock and to reduce water logging. He feels that knowledge and money are key constraints along with the time required for change creating financial loss.

Combination of farming sectors

When the results were collated in order to consider each of the different combinations for farming sectors (such as those who are farming arable and beef, or sheep and poultry), the highest responses were for arable farmers who also diversified or included other non-farm sectors, such as light industrial units and wind turbines. Whilst many of the permutations reflected more than one respondent, the majority of groupings were only farmed by one farmer per group (see Figure 5-4 below).

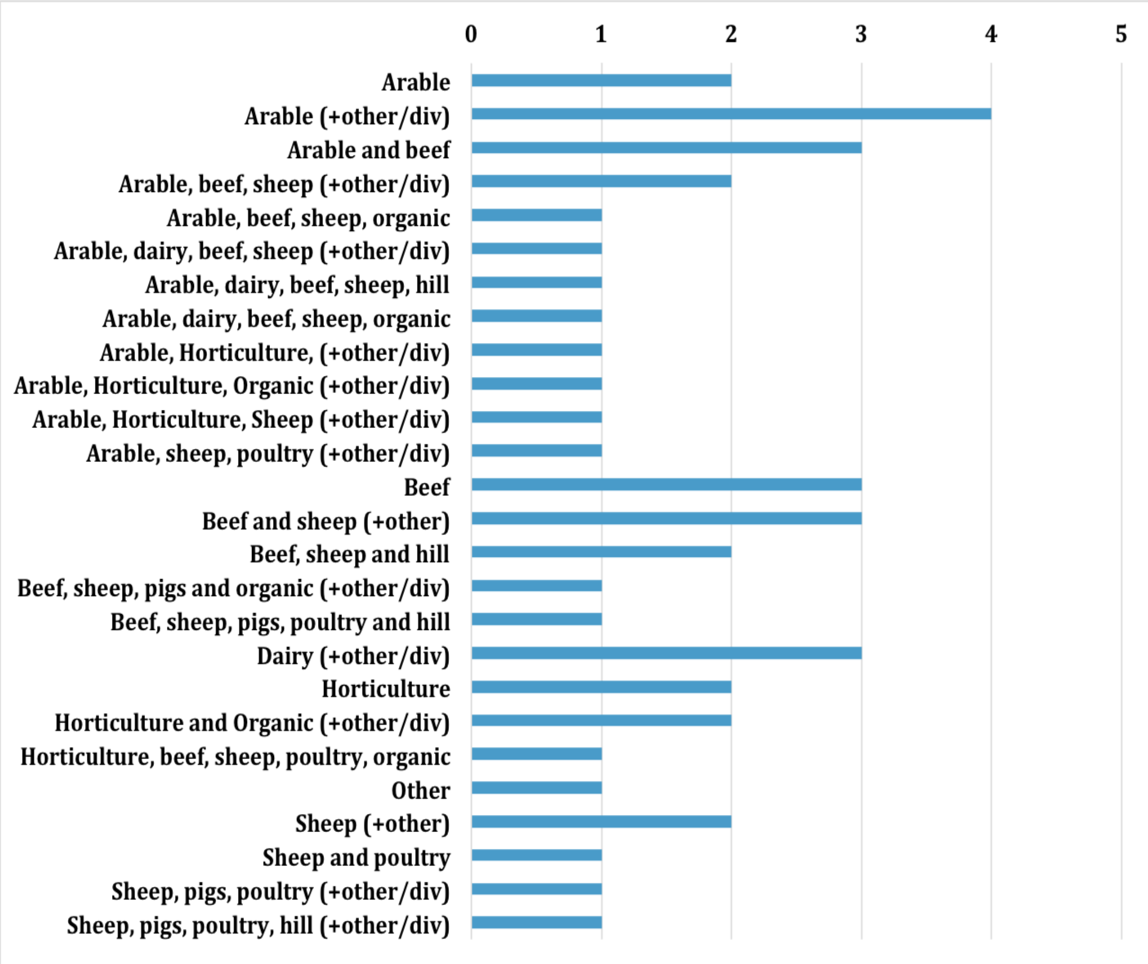

Figure 5-4 Showing the groupings of the survey's farming sectors against the number of respondents

The breakdown of comments for the diversification / other categories in the above data is shown in more detail in the Table A8.1 in Appendix 8, but includes some examples shown in the farm snapshot boxes throughout Section 5.2. These include holiday cottages and glamping, education centres and alternative sale products from fruit and flowers, to selling in farmers' markets.

5.2.3 Region and farming sector

When exploring the respondents with both their farming sector and their region, those living in the Midlands had the greatest variety of different farming sectors between the farmers, with the South-East, South-West and North-West following behind. However, the range of different farming sectors is possibly simply due to the number of responses from those regions as shown in Table 5-1 below.

Table 5-1 Showing total numbers of respondents per region (Tot=total), and the sectors they farm

Region	Tot	Arable	Horticulture	Dairy	Beef	Sheep	Pigs	Poultry	Hill farming	Organic	Diversification	Other
East	3	2	0	0	1	0	0	0	0	0	1	1
Midlands	12	9	4	1	6	6	1	2	0	3	5	8
North-East	1	0	0	0	1	2	0	0	1	0	0	1
North-West	3	1	0	1	2	3	1	1	2	0	1	1
Yorkshire	1	0	0	0	0	1	0	0	0	0	0	1
South-East	7	4	1	0	2	3	0	2	0	1	2	3
South-West	5	0	1	2	2	2	1	0	0	2	2	3
N Ireland	2	0	0	0	1	1	0	0	0	0	0	1
Scotland	1	1	1	0	0	1	0	0	0	0	1	1
Wales	6	0		1	4	2	1	1	2	0	0	0
Not identified	2	2	0	1	1	1	0	0	0	0	0	0

For Northern Ireland, North and South Wales, these responses only came from two to three farming sectors (beef and sheep for N. Ireland, beef, sheep, pig, poultry, dairy and hill farming from N. Wales, and horticulture and beef for S. Wales). The North Wales results were not surprising concerning sheep and hill farming, as that region is hilly, but the Scottish result suggests possibly that the respondent did not live in the highlands as they were farming arable as well as horticulture, sheep and diversifying. The remaining regional results were spread between the sectors.

5.2.4 Gross turnover, farm size and ownership of farm

Whilst two responses in question 4 of the survey did not reveal their region, all respondents indicated their gross turnover and farm size as shown in Tables 5-2 and 5-3 below. Looking at the gross turnover, farmers earning between £100K-£500K had the highest response at 44%, whilst the lowest was £40-£100K with only 9% response rate (as shown in Table 5-2 below). Three of the five farmers with the largest gross turnover were from the south, and eight of the twelve Midlands based farmers were from the next lowest bracket (£100-500k). Given the number of responses for the £100-500k category, in hindsight it may have been better to break that category into two, which might have generated a wider spread of results. Looking at the farming census for gross turnover and farm size for 2014 (DEFRA et al. 2015), it is not possible to do a direct comparison to the Phase 1 result due to different breakdown of categories.

However, a table showing the census figures for farm business income (Table 5-3) is shown alongside the survey results, and considering the gross turnover of the survey respondents, a greater proportion from the higher brackets of gross turnover and smaller proportion from the lower brackets completed the survey, than the census figures of all farms in the UK.

Table 5-2: Showing gross turnover for the respondents

Please indicate your gross turnover bracket 1000'(k) £ per year	Count	Percent
<£20k	7	16%
£20k-£40k	7	16%
£40k-£100k	4	9%
£100k-£500k	19	44%
>£500k	6	14%

Table 5-4 Showing 2014 census figures for farm business income from (DEFRA et al. 2015)

DEFRA Farm business income 1000'(k) £ per year	Percent
<£20k	50%
£20k-£30k	11%
£30k-£50k	15%
>£50k	24%

Table 5-5 Showing size of respondent's farms

Please indicate your farm size:	Count	Percent
<20ha	9	21%
20-40ha	5	12%
40-100ha	9	21%
100-200ha	8	19%
200-500ha	10	23%
>500ha	1	2%
Other 1200 ha	1	2%

Table 5-3 Showing census 2014 number of farm holdings by size group from (DEFRA et al. 2015)

Farm size group:	Count	Percent
<20ha	95000	45%
20-50ha	41000	19%
50-100ha	33000	16%
>100ha	42000	20%

With the question regarding the size of the respondent's farm, this was spread far more equally across all options with responses varying from two (for farms greater than 500 hectares) to between five-ten responses for all the remaining farm size options (see Table 5-4). Considering the 2014 census results of farm size (Table 5-5), the figures are quite different to the respondents, with 46% of survey respondents on farms greater than 100 hectares, whereas across the UK this figure is only 20%.

Equally, the percent of survey respondents under 20 hectares is under half that of the census (21% rather than 45%).

Of the forty-three respondents, forty indicated that they own their own land. However, of those forty, fourteen also rented land. One farmer also indicated that they contract farmed 50% of their crops, owned 25% and rented the other 25% of the remaining land. Of the three who only rent their farms, it could be assumed that they may be less likely to adapt environmental behaviour such as adding solar panels, and therefore may not be as resilient to shocks and hazards such as those from climate change as those who do own their own land. All three were in the smallest farm size category, with the lowest and second lowest categories of gross turnover, and one indicated that they did not benefit from subsidies from environmental schemes as their landlord received the money. However, looking specifically at the environmental techniques, of those results, the results were as varied as those farmers who owned all their land or had a mixture of owned and rented.

Farmer R farms in a hill farm in the North of Wales, and he farms beef, sheep, pigs and poultry. His farm falls in the second largest category (200-500 ha), but his gross turnover is in the second largest category (£100k-500k). He both owns and rents parts of his land, and is not a member of any environmental scheme. He has not calculated his carbon footprint, but has experienced 'extreme weather patterns'.

He does manage his manure, but feels that collecting rainwater, or getting renewables would be too expensive and money is the main constraint to him farming agroecologically.

Farmer Z lives and works in the East of England farming arable and renewables. The farm gross turnover (greater than £500K) and size are both significantly large (1200 ha) and the farmer owns his land. The farm is part of DEFRA's subsidy schemes only, but the farmer has also calculated their carbon footprint using the Country Land and Business Association's (CLA) calculator. In addition to renewables, he also employs minimum tillage techniques, whilst planting deep rooting plants, and maintaining permanent soil cover. The farmer comments that 'Direct drilling of rape and beans has reduced establishment costs without any yield penalty and has given confidence to move increasingly towards no-till.'

5.2.5 Environmental schemes and carbon footprints

The environmental scheme question asked the respondents if they were in a variety of environmental schemes such as organic, biodynamic or LEAF[69] which could potentially improve their financial assets. The question also helped to indicate if they were already beginning to farm with climate-resilient or AaSF techniques (it was then followed up later on in the survey, in question 15-16 which asked about specific techniques the respondent was using). The question also included DEFRA's environmental stewardship schemes such as ELS, OELS and HLS (farmers in Wales, Scotland or Northern Ireland who were in equivalent schemes indicated that in the other section at the end of the question). The schemes were chosen during an initial literature review in 2011-12 to help inform the developing the aim, research questions and focus of the study[70], where these organisations were noted and discussed as schemes for sustainable agriculture. However, after evaluating the results, it would appear that no farmers indicated that they belonged to biodynamic and freedom food farming schemes.

Of the forty-three respondents, thirty-two were in an environmental scheme and eleven were not. Table 5-6 lists all the schemes in question 9, with the percentage of respondents for each scheme.

[69] Linking Environment And Farming (LEAF) – a scheme set up to promote sustainable agriculture, food and farming including a Marque standard for products in-store (Public Health England 2014, NHS 2016).
[70] This initial literature review was merged into the current Chapter 2, except where schemes and interventions ceased to exist or were no longer relevant to the study. As a result, the remainder of schemes and interventions can be found in the latter half of Appendix 1.

Table 5-6 Showing percentage of the 43 respondents in an environmental scheme.

Environmental Scheme	Percentage (rounded to nearest whole number)
DEFRA's environmental stewardship schemes such as ELS, OELS and HLS	63%
Other schemes (including Glastir and PFLA)	33%
Certified organic farming (e.g. Soil Association, OF&G, OFF)	19%
Soil Association Low Carbon Farming project	7%
Supermarket scheme (such as M&S)	5%
LEAF	2%
Permaculture	2%
Freedom food	0%
Biodynamic	0%

There appeared to be confusion with the responses to organic due to it being an answer for both question 5 (farming sector) and question 9 (environmental scheme). In question 9, 19% indicated they were part of an organic environmental scheme, which was two more than the organic answer to question 5 above. Whilst there were no comments explaining why they did not complete the organic answer for both questions, they might have either felt that whilst they were in the organic sector they would not call it an environmental scheme, or that they did not see the point in answering it for both question 5 and 9.

Those participants who indicated that they were part of another scheme mainly consisted of devolved government farm subsidies, although two were members of the PFLA and one of those was a member of Regenerative Agriculture. These two respondents also contributed to the Phase 2 data collection.

Whilst the majority of those who answered were in one form of environmental scheme or another, of the forty-one respondents who replied to the 'do you know your carbon footprint?' question, 68% did not know their carbon footprint. Of the thirteen who did know their carbon footprint, most had discovered it as part of a scheme they took part in such as the DairyCo scheme (AHDB 2015). Six had calculated it themselves, with two using the Farm Carbon Toolkit calculator (Smith 2014), whilst two others used the CLA calculator (Country Land & Business Association 2015c). The last two calculated their carbon footprint manually with one of those two farmers claiming that their carbon footprint was neutral 'for seed to consumers' emissions and all farm sequestrations' (Farmer response in survey, winter 2013-14). Of those who selected organic for question 5's farming sectors, four of the six respondents did know their carbon footprint.

5.3 Hazards, shocks, stresses and constraints that participant farmers are experiencing

The hazards that could impact on farming and barriers to changing access to resources or changing farming techniques were explored in multiple questions across the survey. Initially, question 11 examined a variety of environmental impacts that the farmers might experience, from reduced water or increased flooding, to crop failure and animal health, whilst question 12 allowed the respondents to share their actual experiences of those hazards.

Questions 15-16 on agroecological techniques then queried the hazards and barriers that hindered the ability of the farmer to apply that technique.

Finally, in question 18 at the end of the survey, the respondents were asked what other constraints were hindering the farmer from farming in a climate-resilient fashion. Some respondents described stresses and barriers that affected either their ability, such as lacking knowledge to change farming techniques, or to access resources which could help them farm in a more 'climate-resilient' way.

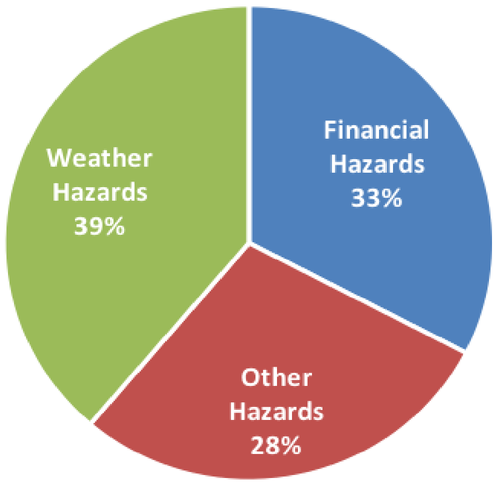

Figure 5-5 Showing hazard codes compared by number of items coded.

Figure 5-5 above shows the number of times hazards are mentioned across the surveys, from changing weather patterns (top); hazards related to financial issues (bottom left) and other hazards such as animal issues (bottom right) and they are each discussed further below.

5.3.1 Agricultural impacts from changing weather and climate

Question 11 was the main question in the survey to consider impacts from weather and climate that the respondents' farms were experiencing. Set as a grid, multiple questions were asked under one topic.

The question 11 grid gave a list of hazard, shock and stress topics, which are listed in Table 5-7 below (see Table A8.2 in Appendix 8 for question grid).

Table 5-7 Showing the percentage of the 43 respondents who had experienced each agricultural impact (question 11a) and the percentage who felt the impact was under control (question 11c)

Agricultural impact	Question 11a (to the nearest whole number)	Question 11c
Increased flooding	51%	47%
Anything else	42%	38%
Crop failures	40%	40%
Water shortages from rainwater	37%	39%
Increased pests, disease and weeds	28%	57%
Lower river levels	9%	46%
Water shortages from piped water	7%	79%
Top soil loss	7%	28%

There were three questions for each topic, question 11a assessed if the respondent had experienced an impact to their farm from the described hazard listed above, question 11b asked for descriptions of the impact, and then question 11c asked if the respondent felt they had the hazard under control.

When examining those who responded that they had experienced an impact (question 11a), only six farmers answered negatively for every agricultural impact, the majority (37) respondents had experienced one or more hazards, shocks or stresses and the percentage of respondents to each hazard is shown in Table 5-7 below.

Looking in more detail at the comments for ‘anything else’, this last response was mainly related to concern over the impact of weather on various aspects of farming from weathering of yard tarmac, to crop and animal loss, and is discussed further below.

Of the forty-three respondents, only thirteen gave evidence of the agricultural impact of the weather they had experienced on their farms in question 12. Analysing the qualitative responses to all the questions for Q11b and the anecdotal evidence from question 12’s responses, the majority were concerned with weather. There were significant references to generalised extreme weather events from ‘less predicable weather’ to a comment that is more comprehensive stating:

> ‘Stress to livestock caused by bad weather/shortage of grass etc. - we can't fine-tune stocking levels on a week-to-week or even seasonal basis! Damage to tracks caused by erosion. Dealing with fallen trees after severe weather. Living in an isolated area when severe weather affects services. The effect on us farmers of working in very bad weather for long periods of time’ (Farmer response in survey, winter 2013-14).

The latter part of this comment also considers the emotional and psychological stress that farmers can experience whilst farming in a variable climate such as the UK.

There was almost the same number of qualitative responses to excessive rain (generally related to the flooding question), little rain (water shortages – rain water) and drought (these answers were spread across all three water shortage questions). These hazards caused a variety of impacts from crop failures, soil loss, excessive slugs, to livestock distress (from lack of water or lack of hay to feed them). Specific qualitative examples of extreme cold, flooding and snow were less frequent with only one farmer from the North-East being affected by harsh cold winters with heavy snowfall. Interestingly, despite the South-West (Somerset levels) having the most news about flooding over the winter 2013-14 (BBC News 2014, Carrington and Morris 2014), the responses indicate that of the forty-three respondents, higher numbers of respondents living in the Midlands stated that they had suffered more from flooding of their farms. This result could be skewed by the number of respondents from the Midlands. However, another possibility is that as the question asked the farmers to comment if they were experiencing increased flooding compared to thirty years ago, more of those in the Midlands perceived flooding on their farms over the longer time period (rather than experienced flooding for the last couple of years).

When investigating UK flooding since 1990, the Midlands had experienced three major floods in 1998, 2000-2001 and 2007 with the North also experiencing flooding with the latter two years above (Hannaford 2015). Furthermore, when exploring the news further, the river Severn flooded in 2013 to a similar extent as in 2007 (Thorne 2014), so this may have influenced those in the West Midlands who completed the survey from December 2013. Examining the data further, it was not only respondents in the Midlands, but also the North-East, North Wales and the East of England who indicated that the respondents had experienced more flooding impact than those who had not. As a result, it is not surprising that the Met Office's records of past weather events since 1990, indicate that there have been a series of flood and record rainfall events across the country over the last 27 years (Met Office Hadley Centre 2017). In fact, only in 2006 did the Met Office record only dry weather and no extreme rainfall or flooding events across the whole of the UK (Met Office Hadley Centre 2017).

As mentioned in Chapter 2, between 2010 - early 2012, the UK faced many drought conditions and for 2010 and 2011 much of England received less than 85% of the average rainfall for the country, within the Midlands and the East of England, less than 75% of the annual average rainfall fell in 2011 (Kendon et al. 2013). Of the nineteen who gave qualitative responses, eight specifically mentioned low rainfall or drought. Four referred specifically to 2010-12, with comments such as 'Stream (used for watering livestock) dried up in summers of 2010 and 2012’. One farmer gave very specific descriptions of how his farm had coped during the drought:

> ‘In May of 2011, the East of England was experiencing its driest season in 101 years. Farming on heavy moisture retentive clay the farm performed well relative to other soil types and is relatively well placed to deal with the problem. Nevertheless, high temperature and moisture deficits did affect yield and such events if they increase in frequency as predicted will cause a long term effect in farm productivity’ (Farmer response in survey, winter 2013-14).

Four respondents also referred to water shortages in the year that they completed the survey (2013-14) with comments including ‘Lack of rain in this year’s spring affected crop & grass yields’ (Farmer response in survey, winter 2013-14). Of those four, one referred both to the drought in 2011-12, and then water shortages and a possible drought against this year:

> ‘We have several schemes in operation for conserving water but we have many concerns about droughts - this summer was the driest we have experienced here…. Our brook… has been very very low this summer. We use it for drinking water for stock and very low levels can even enable sheep to cross onto neighbouring land!... Our usual harvest used to be 70-90 big bales of hay. In 2011 we were only able to make 14 big bales of silage because of drought; in 2012 we made 200 - but the quality was very very poor. This year we made some early - but then ran out of grass because of the drought and had to feed a lot of it before winter!’ (Farmer response in survey, winter 2013-14).

Of the forty-three respondents, only nineteen individual farmers gave qualitative examples of difficulties due to weather impacts on their farms (either in question 11 or question 12). However, as discussed in Chapter 4, Fishers Exact Test was used to assess if there was significance between those experiencing flooding and recording it. As expected, there was significance between those who have not experienced increased flooding and therefore did not record evidence (p=0.047). This results for this are shown in Table A8.3 in Appendix 8. Less expected, although not significant was that of the 22 respondents who had experienced increased flooding, 12 had no evidence of the flooding. This raises the question about why they had not recorded: did it occur too regularly, or did they feel it was under control and therefore did not record it.

Looking at the data, it would appear that the 12 who did not record evidence also did not feel they had it under control and more specifically, one farmer indicated that the lack of control was because their farm was used as a flood defence scheme to protect a local town. This lack of control and lack of evidence might indicate farmers less willing or more willing to change their farming technique, but without further data, it would not be possible to confirm (this is discussed further in 5.4.3). If the survey was repeated, it may help to have the evidence question after each impact rather that as a separate question, as some of those who said they recorded evidence, discussed other impacts such as crop failures.

Most of the financial responses of stress or shocks were related to hazards from the weather that affected the financial assets of a farm, as there was not a specific question asking the farmers about impacts changing financial elements of their business. This section therefore, considers both the areas where the hazards create financial stresses for the farmers (such as outgoing costs straining finances as they were not budgeted for), and the few specific financial problems mentioned in the survey that are not related to weather.

Of the respondents who mentioned finances in relation to shocks and stresses, all comments were in response to the question 11 and 12 regarding agricultural impacts, except one respondent who in response to question 15e regarding using energy reduction techniques replied ‘energy is expensive, we've always been careful. There's never been the money to throw about’ (Farmer response in survey, winter 2013-14).

Regarding the other respondents who indicated financial issues in relation to hazards, these included reduced amounts of rainwater (Q11b) reducing crop yields (thus potentially a reduced income from their crops), and ‘Land flooding that has never flooded before - new drainage needed’ (Farmer response in survey, winter 2013-14), which would most likely require an outgoing expense.

Answers concerning increased pests and diseases (Q11e) leading to crop loss included increased slug activity (reduced income) and treatment costs for ‘unexpected outbreaks of disease such as very severe out-of-season orf[71] following 2012 very wet dark year. Other diseases such as liver fluke have added to farm costs because of extra treatments being necessary’ (Farmer response in survey, winter 2013-14) (outgoing expense, possibly leading to a financial stress).

A number of farmers commented with regards to crop failures (Q11g) including ‘in 2012 there were many crop failures due to the weather’ and ‘water-logging of crops is a severe threat and can cause complete crop failures. The wet autumn last year caused almost complete crop failures over 300ac of beans and partial crop losses in other crops’ (Farmer response in survey, winter 2013-14).

With regards to anything else that affected their farm business (Q11h), comments varied from high prices of resources, coinciding increases in costs along with lower incomes impacting farm businesses, and damages to unusual crops such as flowers. One farmer wrote he had experienced: ‘stock losses, increased winter feed requirements and subsequent increases of costs teamed with lower income due to stock losses’ (Farmer response in survey, winter 2013-14).

Some farmers found they needed machinery to hire or purchase which previously were never needed ‘Never had a grain dryer on the farm and always managed. But in the last ten years, there seems to be an increase of difficult harvest and used a dryer for the first time last year (Farmer response in survey, winter 2013-14).

Question 12 also gave the respondents the opportunity to share their experiences of agronomic impact and included references to financial loss from replacing loss of livestock, to restoring topsoil loss after excess rain.

[71] Orf is a skin disease mainly on sheep and goats, but can be transferred to humans (Milman 2015).

5.3.2 Other issues causing hazards, shocks and stresses

Looking across the survey results for other shocks and stresses, the qualitative results appear mainly in the questions 11 and 12 agricultural impact results. However, a few appear across the other questions (question 14 regarding long term planning, question 15c regarding collecting water, question 17 considering successful methods farmers have found for dealing with problems, and question 18 on barriers to change).
The main qualitative comments regarding shocks and stresses were related to animal health (previously mentioned above specifically with regards to financial costs); government impact, interference and input; pests on crops; and soil.

Examining the five animal health comments, two were quoted above in 5.2.1 and 5.2.2. However, other farmers were also worried about the impact of the climate and nature on their animals, with new diseases emerging 'impact of climate on health - Bluetongue Schmallenburg [sic]' and of collected rainwater, stating 'worried about safety for drinking water for cattle (Farmer responses in survey, winter 2013-14). These comments also link to government policy as another farmer commented 'We haven't suffered from diseases such as Schmallenburg [sic] directly but such diseases influence farm vaccination policy' (Farmer response in survey, winter 2013-14).

Six farmers responded concerning the Government interfering and affecting a farmer's day-to-day activities, hindering their livelihoods and creating excess stress (through increasing costs, new policies of vaccinations or regulations, excess paperwork and bureaucratic difficulties). One commented indicating non-interference from the government with regard to experiencing increased flooding, stating that the 'Environmental Agency do not clean out rivers any more', whilst another farmer in response to constraints to farming more agroecologically, responded:

> 'Suggest that the major constraint is DEFRA and its refusal to acknowledge sole [soil] ecosystem degradation. In particular the refusal to recognize [sic] the benefits of reinstating saw [soil] organic matter that has basically

halved over the last 3040 years[72] on arable land' (Farmer responses in survey, winter 2013-14).

Whilst the main pests influencing crops that farmers commented on were slugs, pollution from the slug pellets also caused problems to the soil:

> 'Prolonged periods of wet weather such as those experienced in October of this year and during last autumn as well as consistent precipitation throughout summer increase the slug burden which can cause complete crop loss (100ac of wheat lost to slugs last year). The increased levels of metaldehyde (slug pellets) have caused problems with water pollution with unintended consequences upon other beneficial soil organisms' (Farmer response in survey, winter 2013-14).

The remaining comments regarding soil stresses were due to soil loss following excess rain.

Another issue which has caused undue stress to the farmers included the electrical infrastructure of the local area 'Have plans passed for a wind turbine but no capacity on electricity network so scheme is at a standstill…. There has been no investment in the electricity network in 50 years' (Farmer response in survey, winter 2013-14). One farmer experienced stress due to the communication infrastructure, with poor quality broadband disappearing completely in poor weather; another found stress in controlling their crop nutrients due to extreme weather, whilst another farmer found the decline in wildlife affecting their farm business: 'Noticeable decline in the total number of species on and visiting the farm. Also a decline in numbers within species. Except for red kite [and] Buzzards' (Farmer response in survey, winter 2013-14).

All the shocks, stresses and hazards that the farmers have indicated above could influence their assets (from farming techniques, to advice) and reduce their ability to

[72] This farmer who wrote this comment appeared to have some typing errors for soil, so it is not clear if he actually meant to type 3040 years, or something like the Guardian article which discusses how the Earth has lost a third of its arable land over the last 40 years (Farm Carbon Cutting Toolkit 2016).

access resources. Specific barriers to accessing resources or changing techniques are discussed further on in Section 5.4.

5.4 Learning and taking action – further assets and resources

This section relates to both the assets section of the framework and accessing resources section. As farmers learn and act they can improve their assets. Equally, by going to specialist advisors or written publications for help they are accessing resources.

5.4.1 Where do the respondents go for help for hazards, shocks and stresses?

This section considers whether respondents access social and human assets to get help to hazards (such as family or friends), or external resources (such as written publications or specialist advisors).

As shown in Figure 5-6 below, 62% of the respondents indicated that they would go to friends and family for help with any issues they mentioned in question 11. Of that figure, over 70% of those who would go to family and friends showed on a scale of 1-10, that this source was useful (i.e. those selecting 6-10, shown on Figure 5-6 below).

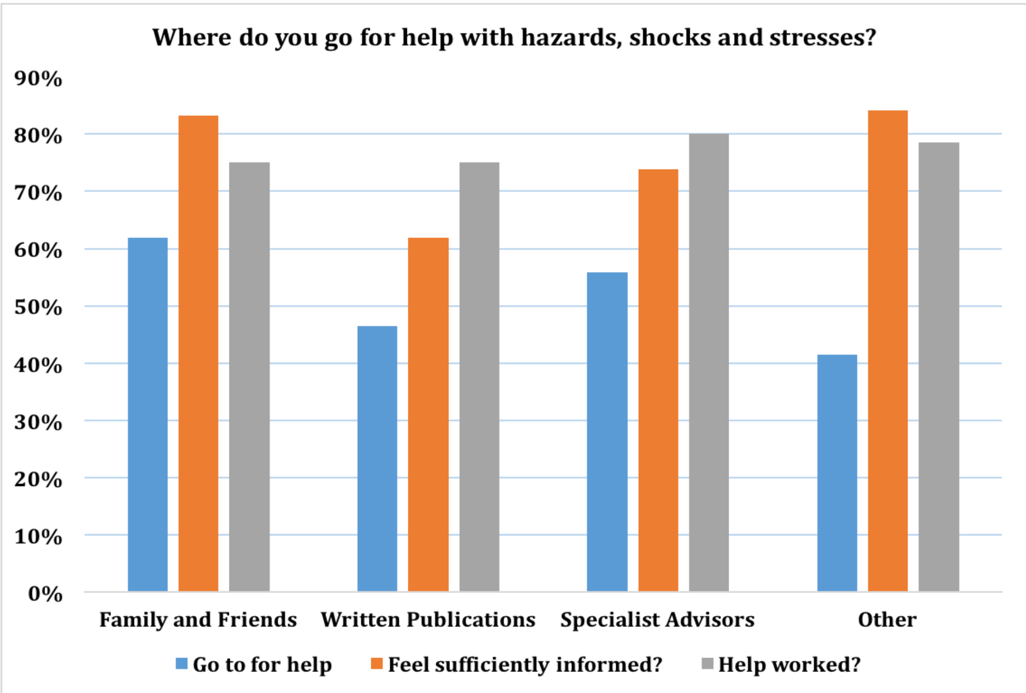

Figure 5-6 showing the responses of those who answered question 13 regarding where they would go for help

Over 83% of the respondents felt sufficiently informed from advice and help given by family and friends, whilst 75% indicated that the help worked. Whilst family and friends would fall into the human and social asset, the help they had provided could boost other assets such as the financial asset through for instance, improved crops.

Using the data reveals different farmers access different resources for help. Fishers Exact Test shows significance between those who do not farm organically, yet go to friends, family and neighbours for help ($p=0.023$) which is shown in Table A8.4 in Appendix 8. Yet when considering the organic farmers, although most do not go to friends and family for help, over half (55%) appear to go to written publications for help, followed by just under half (44%) going to specialist advisors when help was required. These results might suggest that agroecological interventions may need to use different learning resources when encouraging farmers to change. The two advice categories are discussed further below.

Examining the qualitative responses to this question, some responses indicated that their family and friends helped practically rather than offering advice. Others indicated that peer-to-peer knowledge sharing was useful, and that local farmers and friends were *'*Convenient and share similar experiences and solutions', and that 'friends understand local issues and are available 24/7' (Farmer responses from survey, winter 2013-14). Finally, some wrote that the previous generations in their family were a valuable source of knowledge.

Fewer than half the respondents suggested that they would use written publications for help (although as mentioned earlier, the majority of organic farmers did use this source for help), and only 55% of those who would use written publications felt that they were useful (see Figure 5-7).

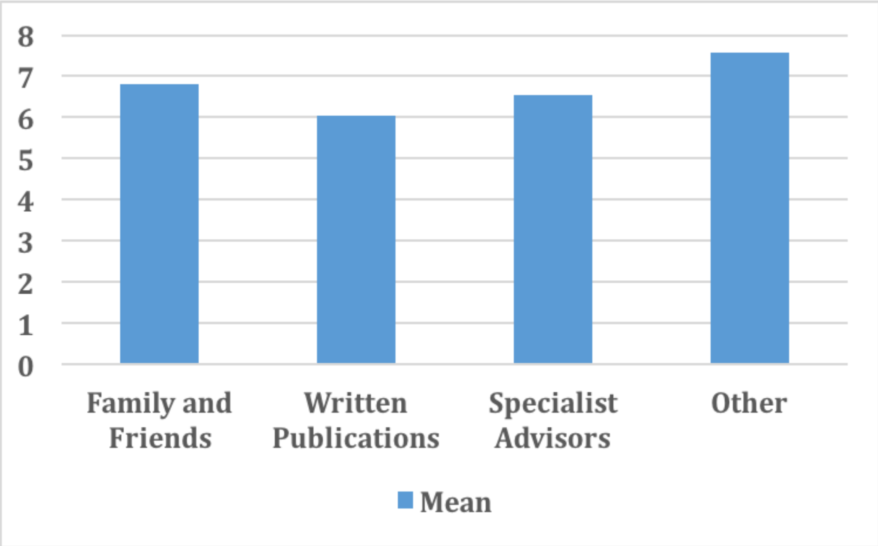

Figure 5-7 Question 13 showing the mean values on a scale of 1-10 (with 10 being very useful) for the question 'how useful is the help provided?' The label other allowed respondents to provide qualitative responses, which are discussed throughout this first section.

Of those who completed the latter half of the question, 61% felt sufficiently informed by written publications, whilst 75% felt the help from those publications had worked. Examining the qualitative responses to this question, two suggested written information on the Internet was useful with one commenting, that the Internet provided the 'opportunity to research a particular issue and gain a wider perspective then that typically offered by DEFRA/NFU' (Farmer response to survey, winter 2013-14). The remainder of responses read industry publications (including those from the NFU), or farming magazines such as the *Farmers Guardian* (FG Insight 2016). One farmer stated:

> 'I do not use newspapers but do use academic journal articles to guide farm practice. Peer reviewed research is in my opinion the most reliable and up-to-date information available to me' (Farmer response to survey, winter 2013-14).

The questions on using specialist advisors scored with only 56% using this source. However, as Figure 5-7 showed, it was the third helpful source of how useful on a scale of 1-10. More of these farmers felt that specialist advisors were useful and some respondents also pointed at specialist advisors, such as vets, in the qualitative comments for ‘other sources’, not seeing them as specialists, but instead falling into another category all together. Of the respondents who answered how informed they felt by following advice from specialist advisors, 74% indicated they felt informed, furthermore, 80% felt the help had helped.

Fishers Exact Test indicated in a DEFRA scheme were significantly more likely to use specialist advisors for help (p=0.004) which is shown in Table A8.5 in Appendix 8. When exploring individual responses, many of those in DEFRA schemes, also sought advice from one of the other categories (18 also used family, whilst 14 also used written publications).

When running the same Fishers Exact Test on arable farmers, as shown in Table 5-8, the test indicated that the those who do farm arable are significantly more likely to seek specialist advisors (p=0.013).

Table 5-8: Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for arable farmers and those going to specialist advisors for help.

			Specialist advisors -- Do you get help from these places?		
			yes	no	Total
Arable - what sector do you farm?	not selected	Count	9	15	24
		Expected Count	13.4	10.6	24.0
	selected	Count	15	4	19
		Expected Count	10.6	8.4	19.0
Total		Count	24	19	43
		Expected Count	24.0	19.0	43.0

Examining the qualitative responses for these questions, they varied from accessing agronomists, suppliers and drainage experts as required, to receiving 'Tailored advice and opportunity to ask questions' and 'Specialist knowledge that is tailored to our farm/soils' (Farmer responses to survey, winter 2013-14).

Considering the qualitative comments for the 'other sources' question (the percentages for the quantitative results are shown in Figure 5-5 above), many referred to the Internet as an 'other source' rather than as part of the 'written publications' question. The responses included using forums, discussion groups and social media to communicate with other farmers acquiring advice from peer-to-peers as they could gain a 'Wide range of knowledge over a range of conditions around the world' and that 'Someone somewhere is already doing what you are thinking about = Confidence to try' (Farmer responses to survey, winter 2013-14).

This concept of a digital electronic peer-to-peer exchange is discussed in the next chapter following the Phase 2 data collection.

5.4.2 Long term planning for climatic impacts on the farm

By factoring climate change into a farmer's business plan, assets which might be impacted by climatic hazards, such as crop failures reducing the financial asset, could be strengthened.

In a positive result, 71% of the responding farmers (only one farmer did not answer this question) stated that they had factored climate change into their business plan for the next five years with regards to mitigating climate impacts on their farms (Q14), which could prove reassuring for future climate impacts on UK agriculture. If it were possible, a further survey of all the participants again five years later could reveal whether or not their plans proved successful.

Of the 29% who had not factored it into their business plan; one farmer contradicted that statement by indicating that they had allocated money towards mitigating against climate change. However, with no further details provided by that farmer, that answer might have been mistakenly selected. Another six farmers who had not factored climate change into their business plans, indicated they had thought about factoring it in but had not yet allocated anything. 63% of respondents in total indicated that they had thought about it, including the six mentioned above who had not factored it into their business plans, however another six indicated both that they had thought about it but not allocated anything, yet at the same time had also factored in time, money or other ideas into their business plan.

As shown in Table 5-9, Fishers Exact Test indicated significance (p=0.037) between those planning long term for climate change and those practising manure management.

Table 5-9: Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those who factored climate change into their business plan and using manure management techniques

			Environmental management techniques for dealing with bulk manure -- Using the techniques?		
			yes	no	Total
Long term planning is required to combat climate change. Are you able to factor this into your business plan for the next five years?	yes	Count	17	13	30
		Expected Count	13.6	16.4	30.0
	no	Count	2	10	12
		Expected Count	5.4	6.6	12.0
Total		Count	19	23	42
		Expected Count	19.0	23.0	42.0

Significance was also found between those who used minimum tillage and planned for the next five years (p=0.017, Fishers Exact Test), as shown in Table 5-10.

Table 5-10: Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those who factored climate change into their business plan and using zero or minimum tillage techniques

			Zero / Minimum tillage -- Using the techniques?		
			yes	no	Total
Long term planning is required to combat climate change. Are you able to factor this into your business plan for the next five years?	yes	Count	18	12	30
		Expected Count	14.3	15.7	30.0
	no	Count	2	10	12
		Expected Count	5.7	6.3	12.0
Total		Count	20	22	42
		Expected Count	20.0	22.0	42.0

Considering the respondents who had factored it into their business plan, only 28% had allocated money in their business plan and 30% had allocated time. Fishers Exact Test for those who indicated they had allocated time in their business plan showed that there was significance (p=0.006) with converting strips of land at edges of fields back to coppices, grasslands, hedges and wetlands (as shown in Table A8.6 in Appendix 8).

61% of the responding farmers indicated they had considered other elements in their long term planning and these comments included changing farming practices to more perennial crops, pastures and rotations to increase soil organic matter, as well as improving drainage, some had installed renewable energy from biomass boilers to wind turbines. One farmer described how he spent money installing a wind turbine to provide revenue to balance any loss in income as they switched to minimum tillage. He went on to write:

> 'Significant time has been spent understanding the likely impacts of climate change on the farm; learning about how best to implement sustainable farming practices; and ways to mitigate against increased frequency of extreme weather events and increased volatility in weather patterns. Trials will be undertaken with different establishment techniques and with cover cropping to better understand possible coping mechanisms' (Farmer response in survey, winter 2013-14).

5.4.3 Agroecological and sustainable farming techniques plus climate-resilient techniques

As with the environmental schemes in 5.2.5, the list of farming techniques in questions 15-16 began in the initial literature review, but was developed into the adaptation and mitigation techniques and AaSF techniques in Chapter 2. As a result, whilst they can still be found within those sections of Chapter 2, there are not necessarily specific section headings for each technique listed in questions 15-16: instead where better suited, they were incorporated into other sections. These techniques were also expected to be answered by farmers who were not necessarily farming agroecologically or sustainably or in an environmental scheme, as some of the techniques (such as renewable energy) could increase the financial asset. Capturing the more holistic and social side of agroecology was planned to be incorporated into the Phase 2 interviews.

Questions 15 and 16 were also grid questions asking if the respondents were using different AaSF or climate-resilient techniques, the length of time they had used the techniques and the size of land they have used it on, and if they are not using the technique, why they are not and would they like to know more. The different farming techniques that relate to AaSF and climate-resilient farming could also be seen as assets that the farmers possessed. Some assets would be human (from their knowledge of farming techniques such as manure management), but others such as rainwater collection could fall under physical assets. These could also be financial assets as if they were collecting rainwater, farmers would not need to purchase it for their cattle.

The techniques mentioned in question 15 were more general and ranged from manure and grazing management[73], renewable energy production and energy reduction techniques, to collecting rainwater. Four farmers answered that they did not use any of the techniques in question 15. These questions are shown in Tables A8.7 and A8.8 in Appendix 8.

Nine of the 47% who used manure management had been using it for ten or more years, with one farmer using it for just under sixty years. Thirteen who were farming livestock were not practicing manure management, and five who were practising it did not farm any livestock themselves. Two felt that manure management was too expensive, and three had not heard about it, whilst three did not have any form of bulk manure on their farms, so did not need to manage it. Given the question actually asked if they used '*Environmental management techniques for dealing with bulk manure to prevent leaching and emissions?*', the results suggest that it is possible that

[73] Otherwise known as paddock, rotary or mob grazing which is defined in Chapter 2.

the responding farmers were unclear as to the meaning of the question, and the two who felt it would be too expensive may have misunderstood the question. However, it was a question tested during the pilot survey (discussed in Chapter 4), so become an area investigated further in the Phase 2 interviews.

63% used grazing management and Fishers Exact Test showed that those farming beef were significantly more likely to be using grazing management ($p=0.010$) as shown in Table A8.9 in Appendix 8, whilst Fishers Exact Test also showed a similar pattern with those farming sheep also extremely significantly more likely to use grazing management ($p=0.004$) as indicated by Table A8.10 in Appendix 8. Sixteen of the respondents had been using grazing management for longer than ten years, whilst four used it on more than 100 hectares and another six across the whole of their farm. Two indicated they used grazing management without farming any livestock, whilst the remainder farmed a selection of dairy, beef, sheep, poultry, pigs and goats whilst using grazing management. Five were farming at least one type of livestock from this list and were not using grazing management. One farmer who was not using grazing management commented '98% of farm is open moorland grazing management is limited to breed type and numbers really' (Farmer response in survey winter 2013-14).

88% of those who rented land did not use renewable energy and, as could be expected Fishers Exact Test showed high significance that those who rent did not use renewable energy ($p=0.009$), (see Table A8.11 in Appendix 8). Considering those who owned their own farms, only 40% used renewable energy techniques. Fisher's Exact Test also indicated significance between those using renewable energy and those reducing their energy use ($p=0.045$). This is reflected in the values in Table A8.12 in Appendix 8. 37% were using, or in the process of building renewable energy schemes, whilst 67% were reducing their energy use. Three were using wind turbines, whilst another three were using photovoltaics and the remainder did not indicate what types of renewable energy they used. Some chose to answer this question stating that they did have renewable energy and then in the comments mention that their renewable energy was due to be installed, whilst others answered it negatively and then mentioned it was due to be installed. In hindsight, an extra answer of 'due to be installed' might have been useful, and would have helped clear up any confusion. Of the twenty-seven who were not using renewable energy, twelve stated it was too expensive, whilst another three felt it would not work on their farms and six were either in the process of investigating it (finding funding, applying for planning), or were waiting for it to be installed.

Given twelve of the twenty-seven of those not using renewable energy stated it was too expensive, one finding which was surprising was that when looking at the gross turnover of the farmers; of the forty-three who completed the survey, Fishers Exact Test shows that there was no significance between gross turnover and using renewable energy ($p=0.755$). However as displayed in Table 5-11 below, the percentage of farmers using renewable energy is less than 50% regardless of their gross turnover, which possibly would suggest that the results might be similar even if the sample was larger.

Table 5-11: Showing renewable energy use against gross turnover

	Farms using renewable energy	Percentage of total
Gross Turnover £100k	6	33%
Gross Turnover above £100k	10	40%

Of those reducing their energy consumption, fifteen did not have renewable energy, and of the two who did have renewable energy but were not reducing their energy consumption, one suggested that they were not reducing their energy use because it was too expensive. One farmer commented 'The whole operation is geared around low impact farming which includes the use of fossil fuels' in response to reducing their energy consumption, whilst another stated that they 'Always use smallest tractor for each job' (Farmer responses in survey, winter 2013-14). One farmer suggested that they use energy reduction techniques, but they were not successful on their farm, whilst another two used energy reduction techniques in their milking parlours.

42% of the respondents collected rainwater and this was spread between those who collected it into a number of tanks, and those who collected it off the roofs of their houses and farm buildings. One stated in relation to rainwater shortages, that ‘we operate a rainwater harvesting system for irrigation - when there is an unseasonaly [sic] warm period we lack the volume of rainwater required’ (Farmer response in survey, winter 2013-14). When exploring the farming sectors, of the sectors which might have required more water (such as horticulture), the majority of farmers did not collect rain. Only the dairy farmers (66%), organic farmers (83%) and the sheep and hill farmers (52%) collected rainwater.

Examining the specific water questions; water shortages (q11) and collecting rainwater (q15) (as shown in Figure 5-8 below), it would appear that of the three respondents, who experienced shortages in piped water, two collected rainwater and another sixteen who did not experience shortages in piped water also collected rainwater. Of the eighteen mentioned above who collect rainwater, only nine of them experienced shortage of rainwater, with another seven who experienced shortages of rainwater not collecting it.

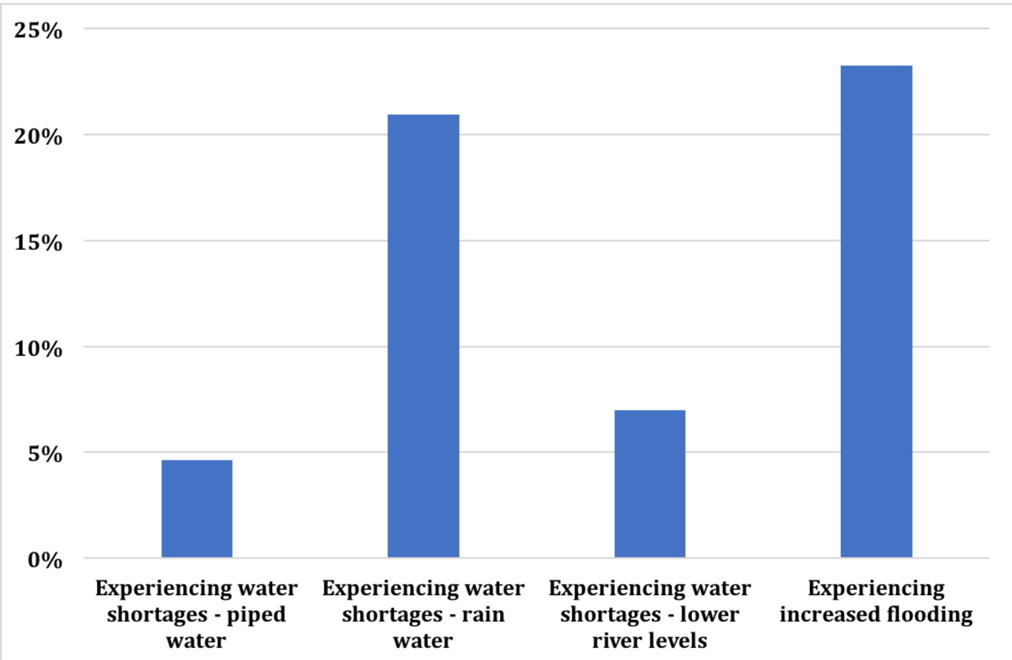

Figure 5-8 showing those experiencing water hazards (water shortages or flooding) and the percentage of those collecting rainwater

Of those who did not collect rainwater, one farmer in the North-West had over 1.5 metres of rainwater a year, whilst another had a spring on their land which provided them with water. Four were in the process of investigating or installing rainwater collection, 19% felt that it was too expensive to apply to their farms and another 12% felt it would not work on their farms. Considering that at least four of those farmers were suffering from a shortage of rainwater, it is notable that they were not considering it, and instead found it too expensive, or that it did not work on their farms.

The techniques in question 16 were related to carbon sequestration and improving soil quality from zero and minimum tillage, and intentionally sowing deeper rooting plants, to maintaining permanent soil cover and converting strips of land (as mentioned above). Nine farmers answered all the question 16 techniques negatively.
49% were using minimum tillage and a Fishers Exact Test showed significance between those reducing their energy consumption and using minimum tillage (p=0.022), maintaining permanent soil cover (p=0.027) and converting land strips (p=0.044) which may correspond to the fact that they do not use their tractors as frequently with those three techniques, thus reducing energy. These are shown in Table 5-12 below, with the rest of the percentages and significance of those using energy reduction techniques

Table 5-12: Showing percentage of respondents using energy reduction techniques with other techniques. (The total number of respondents using Energy reduction techniques was 29). Using Fishers Exact Test, * indicates significance of less than p=0.05. Those without a * are not significant.

Using technique	Using Energy Reduction techniques %
Manure management	52%
Renewable Energy	48%*
Grazing Management	66%
Collecting Rainwater	52%
Minimum tillage	62%*
Deeper rooting plants	34%*
Maintaining permanent soil cover	59%*
Converting field margins	72%*

along with other techniques. The 2x2 tables for the above significance figures are shown in Appendix 8, Tables A8.13-A8.15.

Four farmers had been using minimum tillage for over ten years, whilst six were using it across their whole farm. One farmer mentioned that:

> 'For the last five years rape and beans have been direct drilled (as opposed the former establishment with a plough and associated cultivations) - this represents about a quarter of the cropped area. The goal over the next 5-10 years is to move towards no-till incorporating cover crops if initial trials prove successful' (Farmer response in survey, winter 2013-14).

Of those farming using minimum tillage over the whole of their farms, five had answered it whilst previously indicating that they did not farm arable, only livestock. This may have been because they had permanent pastures that they mowed for silage and hay for their animals, but not arable to sell. This is another question that was further investigated in Phase 2. Of those who did not use minimum tillage, four farmers were pasture only, whilst another six stated that as they were not arable, it would not work on their farms. Of those who were farming arable and not using minimum tillage, four indicated that they did not think it would work on their farms, whilst one indicated that it would be too expensive and another indicated that 'arable crops not managed for carbon capture' (Farmer response in survey, winter 2013-14).

The responses for intentionally sowing deeper rooting plants were quite low (23%), with one other farmer indicating they were about to start implementing this technique. Eleven farmers indicated that it was either not relevant or not suitable for their farms as they were only farming livestock. One farmer pointed out that 'clover in grassland would be good but to many weeds in sward currently' (Farmer response in survey, winter 2013-14) and therefore they were not sowing deeper rooting plants. Other farmers indicated that they would 'trial some multi species cover crops this coming summer [over] 50 ha initially however the intention is to use across the whole farm rotationally if trials prove promising' (Farmer response in survey, winter 2013-14) and that they were using vetch as cover crops. Nearly double (the sowing deeper rooting plants figure) answered that they had pasture or cover cropping (47%), with fourteen stating that their soil had been kept covered for over ten years. One actually stated that it had been permanent pasture for ‘a thousand years or so!’ Some farmers did find difficulties with cover crops and livestock, stating ‘too much red clover bloats cattle so we used a mixed grass seed when replanting’ whilst others simply stated that ‘it works’ when asked why they use the technique. Twelve practiced both minimum tillage and permanent pasture, whilst nine practiced deep rooting plants with permanent pastures. One commented ‘Our farm is in permanent pasture - it is ancient pasture which has never/rarely been ploughed. There is almost no loss of topsoil from this sort of pasture’ (Farmer response in survey, winter 2013-14).

Exploring those who indicated they had converted strips of land back to coppices, hedging, grasslands or wetlands, 61% indicated they used these techniques and several had hedges or coppices for many years. One even stated ‘We've got hedges here over 500 years old every year we try and lay some’ (Farmer response in survey, winter 2013-14). Many also found that wildlife thrived when they used this technique, and some of the previous government schemes encouraged farmers to reinstate field margins ‘For three years land has been dedicated to buffer strips grass field corners and pollen and nectar mixes as a part of the ELS scheme’ (Farmer response in survey, winter 2013-14). Of those that had not converted strips of land back to field margins, the majority of reasons were split between ‘not interested’ and ‘don’t feel it will work on my farm’.

Of those who were farming the arable or horticulture sectors, only one did not practice any techniques that could improve their soil and two farmers indicated that they did not use any of the agroecological techniques suggested. However, one of them did state that not only would they like to know more on some techniques, but also for other techniques they were either looking for funding (renewable energy), or that due to farming in a national park, they were limited in what they could do (in terms of grazing management and converting land).

5.4.4 Successful methods

Twenty-five farmers gave examples of successful methods they use to deal with any of the Q15-16 issues and their answers varied from brief descriptions, to longer specific examples. Figure 5-9 shows the words used, with the size indicating the number of times it was used (so cover crops were the most used terms).

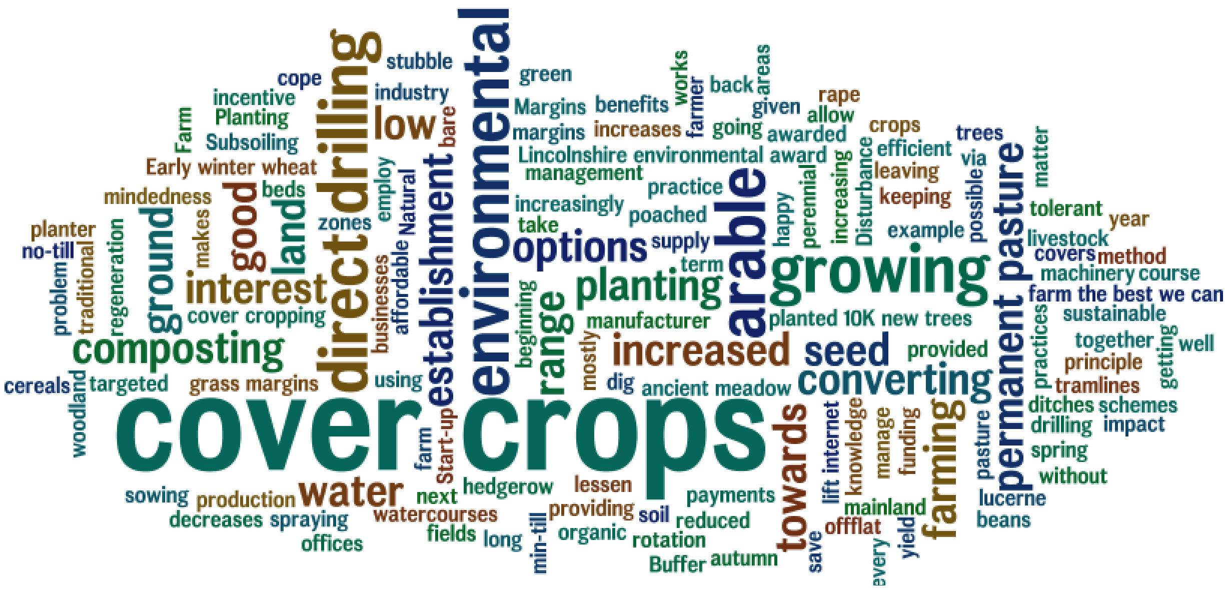

Figure 5-9 Word cloud of author's primary data showing words used to describe successful methods produced by Wordle.net

One farmer gave many different suggestions:

> 'Direct drilling of rape and beans has reduced establishment costs without any yield penalty and has given confidence to move increasingly towards no-till. Increases in machinery manufacturer interest in direct drilling has increased planter options. Increased farmer communication (via the internet in part) is beginning to allow more efficient knowledge transfer. Start-up businesses providing affordable cover crop seed decreases the cost of growing cover crops and increased industry interest increases the range of seed options and supply' (Farmer response in survey, winter 2013-14).

Other successful methods included farmers caring for their land 'Farm is mostly down to ancient meadow - provided I'm careful about not getting the ground poached and keeping livestock levels low we manage OK', and 'using a good range of cover crops and applying the principle of not leaving ground bare if possible' (Farmer responses in survey, winter 2013-14).

Other methods addressing the hazards that the farmers had mentioned from ‘we have planted 10K new trees in areas that were flooding’ to ‘planting trees as windbreaks’. All three of the farmers who had indicated they were planting trees to reduce flooding had answered question 11 stating that they experienced flooding and had no control over it, so as discussed in 5.3.1, it is possible that the lack of control helped encourage them to introduce new techniques and change their behaviour.

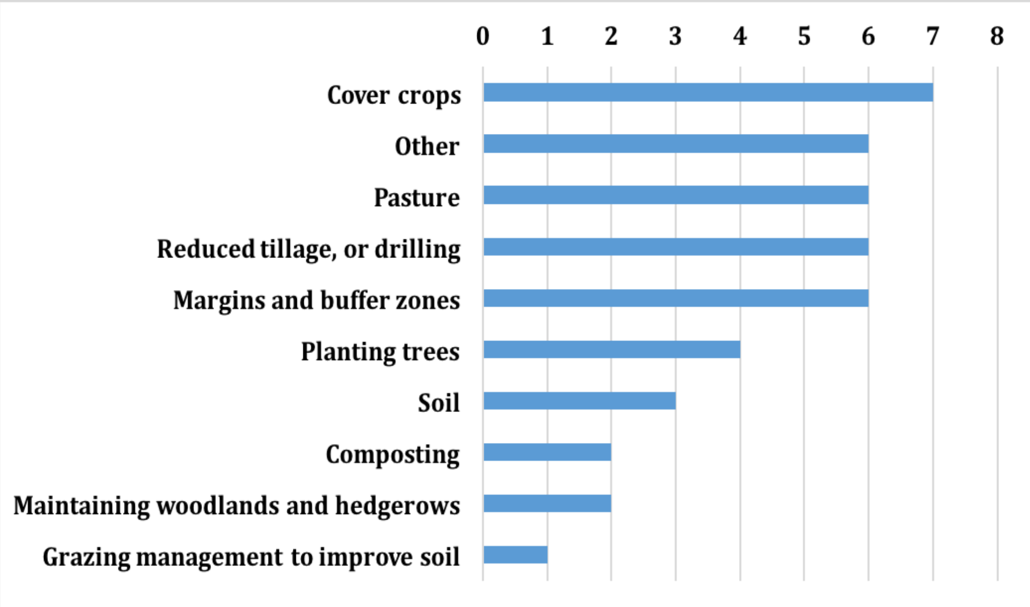

Figure 5-10 Showing successful methods as categorised responses

Summarising the successful methods into ten categories, Figure 5-10 shows the number of responses from converting land to meadows and permanent pasture, minimum or zero tillage, planting trees, to complete frustration with government officials expressed in colourful language (which was categorised as ‘other’), which could be assumed to be more likely to be a barrier to change, as opposed to a successful method.

Of those twenty-five respondents, fifteen were happy to be a case study for future research, and these were farmers who had indicated that they practiced the most agroecological or sustainable farming techniques in their successful methods answer. As it was not a specific question, it is not possible to determine whether the respondents felt the techniques were agroecological or sustainable, and this could be an option for further study.

5.5 Barriers to accessing resources or changing farming techniques

Whilst many of the above techniques can build a farmer's assets, some also require access to resources such as seeds or finances. Constraints and barriers can hinder the farmer's access to those resources. Throughout the latter half of the individual questions for 15 and 16 on why the respondents do not apply a technique, and in question 18 where the respondents were asked what constrains them from farming in a climate-resilient way, the farmers gave responses which could correspond to barriers stopping them accessing resources or changing their farming techniques. As mentioned above, if a farmer does not have the finances to buy seeds to plant cover crops, or knowledge to implement grazing management, this would influence their ability to access the resources where they could buy seeds, or gain the required knowledge.

5.5.1 Why are techniques not being introduced and applied?

As mentioned above, for each part of question 15 and 16 above, the respondents were asked why they were not applying the technique. This has been mentioned with the different techniques in Section 5.3.3 above, but the farmers were given different options based on knowledge gained from the literature review. These were: Too expensive; What is this, I haven't heard about it; Did use it but it wasn't successful; Not interested; Don't feel it will work on my farm and Other. Considering the 'Other' responses in more detail than in Section 5.3.3 above, many of the responses were due to the farms not suiting the technique (a livestock farmer with only grass would not need to till their land). However, some respondents felt the reasoning behind their answer needed an explanation rather than just selecting 'don't feel it will work on my farm', with further responses including those who were investigating the technique or about to implement it. Others responding in this question felt that their system did not suit that specific technique (one farmer felt that converting field margins had no benefit in their no-till system), or they worried about health implications (one respondent was concerned about using collected rainwater to water their cattle).

Figure 5-11 below shows the responses to each technique in terms of why farmers were not using it.

5.5.2 Constraints and barriers

Investigating what hindered the respondents from farming in a climate-resilient way,

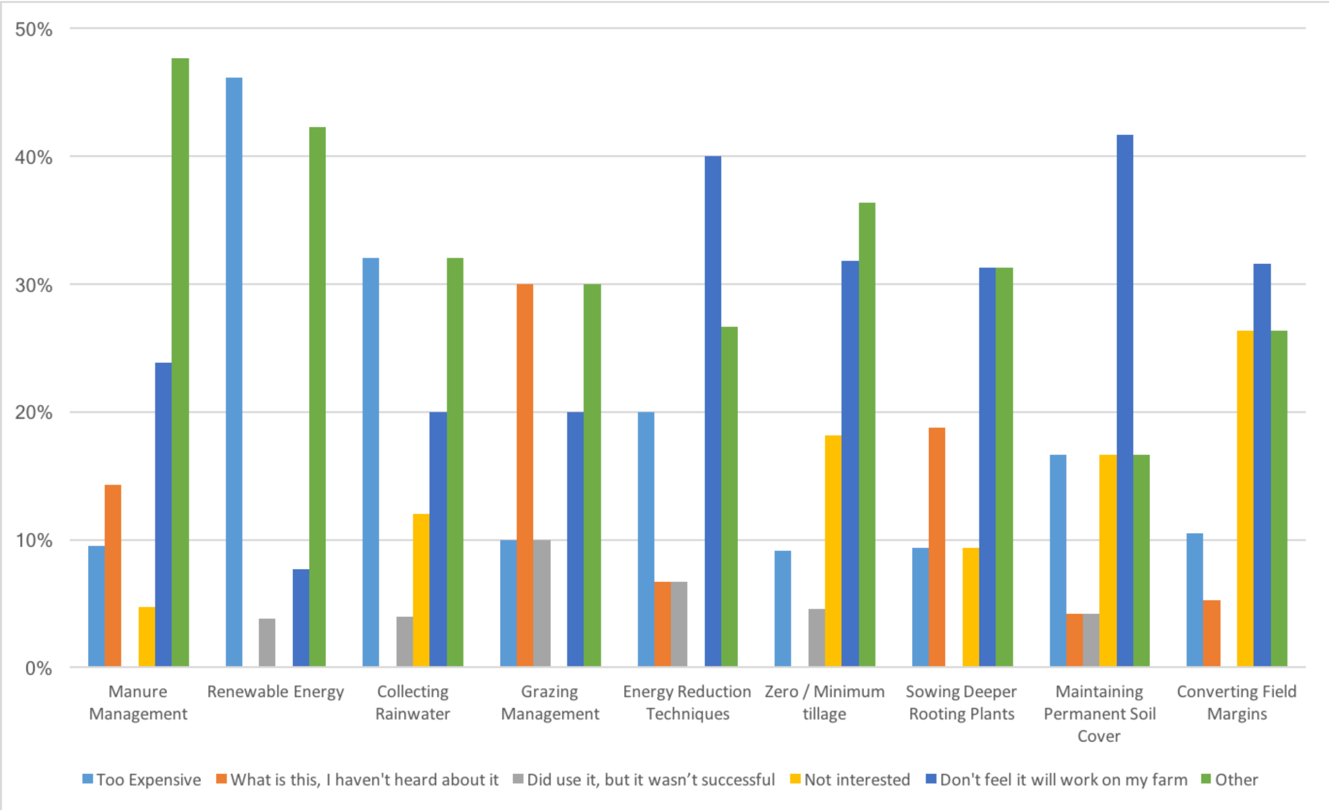

Figure 5-11 showing respondents' reasons for not using a technique

35% of the respondents felt restrained by their lack of knowledge, 63% were constrained by financial implications. Only 12% were not interested, whilst 26% felt the time it would take to change was not worth the financial loss and 28% explained that other reasons constrained them. Fisher's Exact Test showed significance between those who were rearing sheep and felt constrained by lack of knowledge (p=0.027 see Table A8.16 in Appendix 8), whilst those who were not maintaining permanent cover showed significance with the other constraints category (p=0.039 see Table A8.17) using Fisher's Exact Test.

One farmer considered the constraints for not only himself, but to some extent the whole sector, commenting:

> 'With the average age of the UK farmer around 58 there is a reluctance to radically change the farming system later if life. This causes inertia, which will cease as younger entrants replace those leaving the industry. Also many of the environmental costs remain externalities and so there is often no short-term incentive to farm in more sustainable manner. Lastly although not an issue for my farm, short-term tenancies do not allow / encourage tenant farms to farm in a way that is sustainable in the long term because it is in their financial interest to maximise short-term profitability' (Farmer response in survey, winter 2013-14).

Four respondents felt they were already farming in a climate-resilient manner and therefore did not experience any constraints. Others felt they were constrained by government policies and lack of investment in the power and communication networks, business sales men and contractors not up to farming that way, and lack of knowledge (including scientific) that might benefit their farms such as knowledge about soil bacteria.

5.5.3 Other barriers and constraints based on qualitative analysis

When exploring the qualitative comments using NVIVO and coding the results, belief that the techniques would not work on their farm or that they were too expensive were the highest coded barriers mentioned. Some respondents who offered comments regarding the survey, had previously communicated on Twitter or TFF that they did not believe in most of the news regarding climate change, despite admitting (in the survey) to have experienced changes to the weather in their regions (AgriChatUK 2013, The Farming Forum 2014).

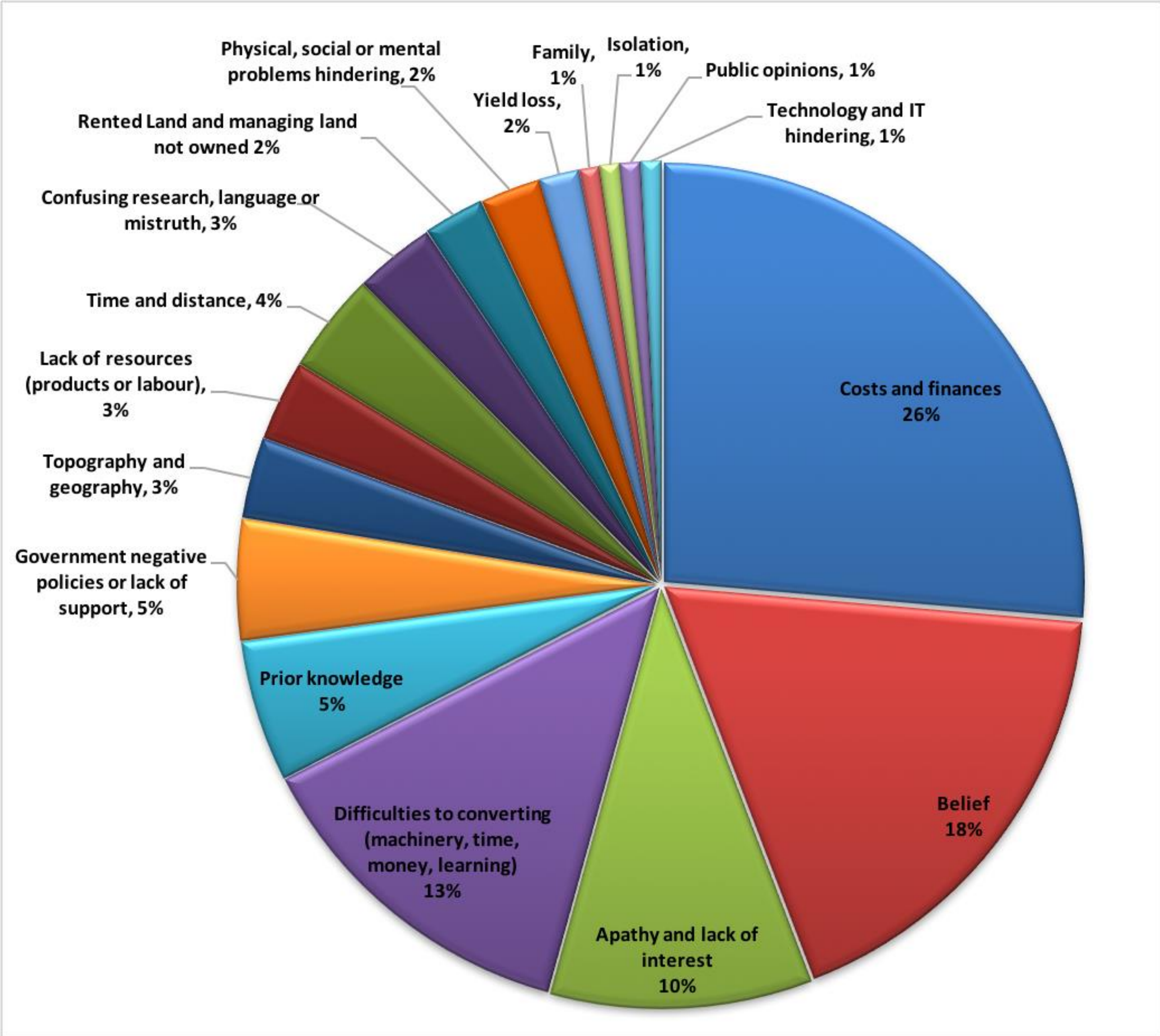

Figure 5-12 Showing different barriers and constraints from analysing the qualitative comments

Other barriers (as shown by Figure 5-12) on the previous page included lack of interest or apathy, difficulties to converting such as changing machinery (one farmer mentioned ‘we're south Cumbria, no one has that sort of tackle for the 10 hectares of barley we put in occasionally’) and prior knowledge that technique would not work on their farm.

5.6 Other themes relating to the analytical framework

By analysing both the quantitative and qualitative comments from the Phase 1 survey, other themes that relate to the analytical framework have emerged. These are generally concerned with building or reducing assets and resilience to hazards.

5.6.1 Soil loss and soil improvement

There were specific questions in both the hazards question (q11 – top soil loss) and the techniques (building assets) questions (q16 – tillage, roots of plants, cover crops and field margins) that may have introduced a bias to the data slightly towards a soil theme.

However, Fishers Exact Test showed high significance between those who are part of an environmental scheme and using minimum tillage ($p=0.004$, see Table A8.18 in Appendix 8), whilst the same test also revealed significance between those in a DEFRA scheme and those practicing minimum tillage ($p=0.027$. see Table A8.19). Furthermore, Fishers Exact Test shows significance that between those who were in environmental schemes and those maintaining permanent soil cover ($p=0.039$, See Table A8.20).

Figure 5-13 shows, the percentage of comments throughout the survey related to specific soil topics including direct drilling, analysis and soil nutrients. The minimum tillage, pasture and root structure boxes relate specifically to question 16, so as a result, they appear larger than the other themes.

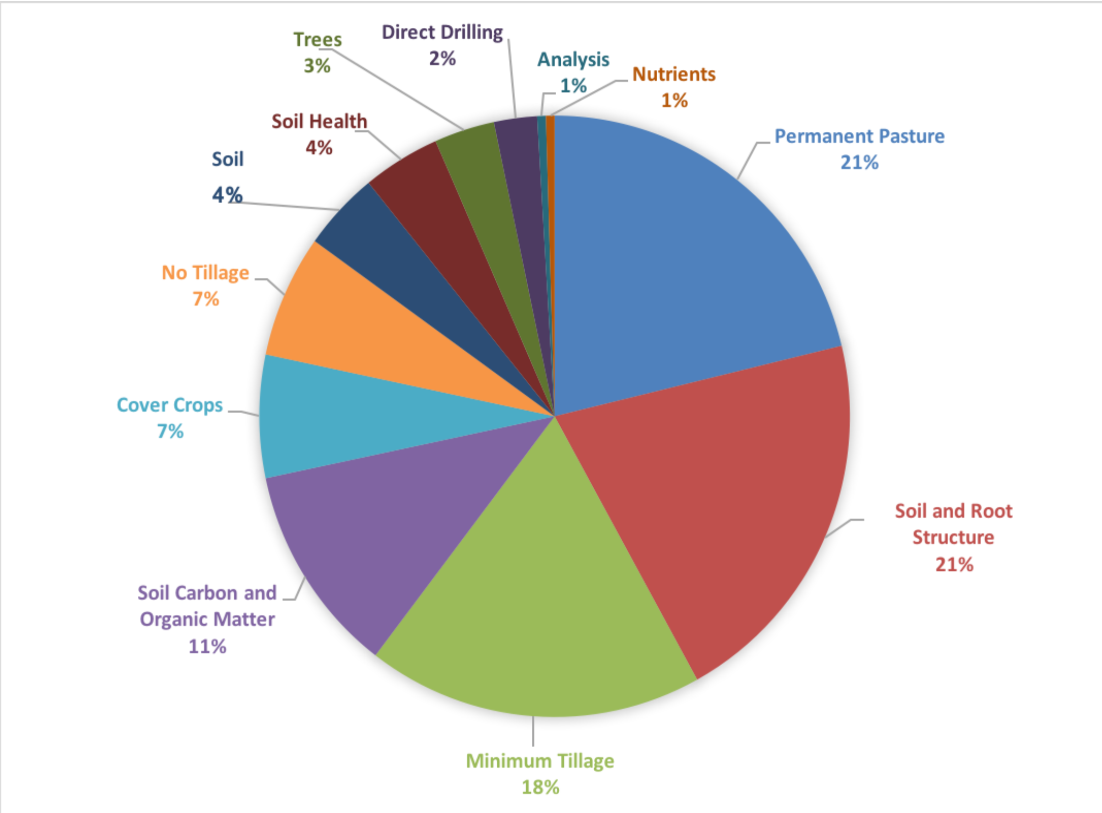

Figure 5-13 showing responses from farmers who mentioned topics related to soil in their qualitative comments

Examining the different farming sectors of the respondents to see if they used minimum tillage, of the forty-three farmers who completed the survey, Fishers Exact Test shows that there was no significance between arable farmers and using minimum tillage (p=0.129). As 63% of those farming arable and using minimum tillage, it could be speculated that if the sample was greater, the results might change and possibly became significant, however without further data collection there would be no way to confirm this. This would also be relevant to the organic sector as at 83% they had the highest percentage of farmers using minimum tillage and therefore a greater sample might lower the significance from p=0.095 to below p=0.05, and thus indicate significance. Looking further at the other sectors that are using minimum tillage, those diversifying show a 75% of farmers using minimum tillage, and also a significant result using Fishers Exact Test of p=0.045. These respondents generally consisted of arable or horticulture activities that used minimum tillage on part of their land (as well as diversifying through activities from education study centres to renewables). However, there were two farmers who did not farm arable or horticulture and they indicated they used minimum tillage on the whole of their farm. This is not surprising as they both indicated they had permanent pasture for grazing their animals.

Considering the answers to those who were maintaining a permanent soil cover, arable farmers scored low with only six using cover crops, whilst the sheep and beef sector farmers scored highest with eleven respondents for sheep and eight for beef. However, given they are unlikely to need to till the soil and instead use mainly grass, it is not that surprising that they maintain the soil cover.

5.6.2 Not collecting rainwater and also not using other techniques

When exploring the 25 who were not collecting rainwater as discussed briefly in 5.3.3, a number of significant results appeared when analysed alongside those who were also not using other techniques, these are shown in Table 5-13 below. If the respondent was not using the technique because they did not have animals on their farm (therefore not using grazing management for example), then it would not necessarily reduce their assets or make them more vulnerable to hazards. However, if they were not using the assets for another reason such as they were not interested, then there is the possibility that it might reduce an asset.

As shown in the table above, Fishers Exact Test showed there was significance between those who were not collecting rainwater and those who were also not using minimum tillage (p=0.014). The same test also showed significance between those not using renewable energy and those not collecting rainwater (p=0.01) and significance between those not maintaining permanent soil cover and those not collecting rainwater (p=0.033).

Table 5-13: Showing those were not collecting rainwater as well as not using another technique. Using Fishers Exact Test, * indicates significance of less than p=0.05, whilst ** indicates significance of less than p=0.01. Those without a * are not significant.

Not using technique below	% Not collecting rainwater
Manure management	52%
Renewable Energy	80%**
Grazing Management	36%
Energy Reduction techniques	44%
Minimum tillage	68%*
Deeper rooting plants	80%
Maintaining permanent soil cover	68%
Converting field margins	40%

Considering those who were not using rainwater collection and not using minimum tillage, 11 respondents were livestock farmers, whilst only 8 were arable or horticulture. This might explain the lack of minimum tillage techniques used (if no crops were grown), but less the lack of rainwater collection (as they could use it as water for their animals). Looking at the reasons why the livestock farmers might not collect rainwater, the responses varied from those considering the possibility, to those who thought it was too expensive, or unsafe for their cattle. Further post doctorate investigation could delve deeper into why a farmer was not using two techniques and what they farmed, possibly making it clearer than the brief example gained from looking at the qualitative data shown in this paragraph.

Table 5-14 on the next page, shows in blue the percentages of farmers using two techniques, and in green the significance level using Fishers Exact Test (p=).

Table 5-14: Showing results of farmers using two techniques. Using Fishers Exact Test, * indicates significance of less than p=0.05, ** indicates significance of P=0.01, whilst those without a * are not significant.

	Manure manage.	Renew. Energy	Collect. Rain.	Grazing Manage.	Energy Red.	Min tillage	Deep. Root. plants	Maintain. Perm. soil cover	Convert. field margins
Total responded answer yes	20	16	18	27	29	21	10	20	26
Manure management	N/A	45%	40%	70%	75%	65%	30%	40%	65%
Renewable Energy		N/A	69%**	69%	88%*	69%	31%	56%	63%
Collecting rainwater			N/A	83%	83%	72%*	28%	67%*	61%
Grazing Management				N/A	66%	44%	19%	48%	59%
Energy Reduction techniques					N/A	62%*	34%*	59%*	72%*
Minimum tillage						N/A	33%	57%	76%
Deeper rooting plants							N/A	90%*	70%
Maintaining permanent soil cover								N/A	75%
Converting field margins									

5.7 Summary

This chapter has explored the results from the farmers' completion of the Phase 1 survey using the analytical framework from Figure 3.1. Some farmers were very detailed and provided thorough answers which revealed a level of understanding about their sector which was less obvious in other farmers' answers. Other farmers filled in only the basic results, possibly due to frustration at the length of the survey, or due to the difficulties experienced with the online survey requiring unnecessary mandatory answers in order to make it possible to move to the next survey question. These issues that were not discovered during the pilot survey (and were discussed in detail in Chapter 4).

The chapter first looked specifically at the respondents and their locations, farming sectors, gross turnover, farm size and environmental schemes they were part of. This aided understanding of the farm households and their assets. The chapter then moved on to consider hazards, shocks and constraints that the respondents were experiencing, including stresses such as animal health as well as hazards from climate and the weather. As some of the regions suffered physical flooding hazards at the time the survey was live, those results were notable regarding the UK geography and the recent winter floods (2014-15, 2015-16).

The chapter then looked at farm assets and resources which could help them build their resilience. This included where the respondents would go for help (with family and friends having the highest result). However, it also revealed that those in a DEFRA scheme were significantly more likely to use specialist advisors for help. In the same section 5.4, the chapter then looked at long term planning for climatic impacts on their farm which revealed that the majority of farmers surveyed had considered climate change in their five-year business plans. This section then finished by looking at AaSF and climate-resilient techniques and successful examples of those techniques from the respondents.

There were also interesting discoveries such as that only one of the arable and horticulture farmers did not practice any techniques to improve their soil and the slightly expected result, that it was significantly likely that the beef and sheep farmers were using grazing management. More unexpected, was that there was no significance between a farmer's gross turnover and using renewable energy (which possibly could relate to the feed in tariffs explored during the Phase 2 interviews, as even the table of percentages indicated turnover did not influence using the technique). Equally, exploring the qualitative results of the question 15-16 about agroecological techniques revealed more like-minded farmers than the quantitative results had shown. As discussed above, many of the farmers commented in the free text sections about the reasons why they did not use a technique, and from those comments it was apparent that those techniques would not work on their farms, or that they were in the process of beginning to use that technique.

The chapter then looked at barriers and constraints to accessing resources and changing behaviour including why techniques were not being used before finally considering other themes which were revealed in the data and which were related to the framework.

The next chapter (6) will explore in detail, the qualitative results from the Phase 2 data collection, that of the individual and group interviews. The results will once again use the analytical framework of the UK Rural Livelihoods Framework described in Chapter 3. The interviews included some who had completed the Phase 1 survey, which might expand on the answers provided in the Phase 1 survey.

Chapter 6 - Phase 2 results: qualitative insights on climate change and agroecological practice

6.1 Introduction

Following on from the Phase 1 results chapter, this chapter discusses the qualitative results of the Phase 2 data collection which ran from September 2015 to March 2016. This phase of the research consisted of the fifteen semi-structured individual and one group interview[74] of farmers, growers and an advisor in England who had used or tried sustainable farming techniques. The interviews ran for between 30-90 minutes. Once again using the analytical framework from Chapter 3.1, this chapter first explores the respondents, their households and assets before considering briefly an initial analysis of the results. The chapter then explores the different hazards that the interviewees spoke about in relation to climate and weather, the human assets and resources that the interviewees have gained through learning and taking action to apply techniques, and finally the drivers and barriers to accessing those resources.

6.2 Considering the respondents – Locations of their households and their assets

Of the fifteen individual stakeholder interviews, eight took part in the Phase 1 survey, whilst seven participated in workshops run by Regenerative Agriculture UK (RegenAG). Five were organic certified, six were part of the PFLA, three had permaculture training, three were categorised as conventional as they were not associated with RegenAG, organic, PFLA or permaculture, and one was an advisor. Five were female and ten were male (which at 33% is considerably higher than both the Phase 1 results, and the national figures quoted in 4.4.1). Three farmed sheep, two beef, two dairy (one cows, the other sheep), two arable, three mixed and one ran a CSA whilst another grew horticulture. The advisor advised on improving soil quality regardless of whether a

[74] Chapter 4 discusses two group interviews, but notes that the second group interview's data was unusable and therefore not of use to this thesis. Hence in this chapter, there is only reference to one group interview.

farmer farmed livestock or arable. Figure 6-1 below shows the locations of those interviewed with those who took part in Phase 1 shown in purple.

The fourteen people in the group interview, were all from RegenAG, and some were also from a permaculture or organic farming background. Those who were interviewed in the group interview are not shown on the map in Figure 6.1 as due to the nature of the group interview, with a set question for discussion and the ketso kits, the location of the group respondents was not discussed. It was also unclear from the group interview what exactly each person farmed, although from conversations about permaculture and organic, those farming sectors became evident.

Figure 6-1 showing location of interview participants. Those in purple were also part of the Phase 1 survey

6.3 Initial analysis

Using a semi-structured interview technique, the initial interview questions used in this phase were drawn from the Phase 1 survey. By allowing flexibility in the semi-structured interviews, during and after the open-ended questions that evolved in each interview, notes were made which drew out topics for future interviews (Bryman 2008). These were then added to the initial semi-structured questions for the next interview.

As discussed in Chapter 4, the group interviews were for RegenAG members. They used creative participatory methods using Ketso kits (Ketso 2016) to debate strengths, weaknesses, opportunities and threats (SWOT[75] analysis), related to how RegenAG could be embedded into the UK farming scene.

After transcribing the interviews, a number of possible key topics, concepts and themes (called codes) were identified and a rigorous search of these codes was applied across all the sources. Figure 6-2 shows all the different codes and meta-categories by the number of coding references for each code. The colours indicate codes within a meta category, and the list meta-categories and responding colours are listed below. Codes in grey were not grouped into meta-categories.

Figure 6-2 Word cloud of author's primary data showing interview coding by number of coding references for each code. produced by Wordle.net

The meta-categories were:

- Animals (shown in orange)
- Barriers and constraints (shown in turquoise)
- Climate (shown in green)
- Education and extension (shown in purple)
- Hazards (shown in red)
- IT, Internet and social media (shown in yellow)
- Soil (shown in brown)
- Water (shown in blue)

[75] The weaknesses and threats could be interpreted as hazards (or as discussed in 6.6 barriers to change), whilst the strengths could be seen as drivers to change (with opportunities possibly also reflecting drivers in some circumstances).

Themes that emerged are discussed in detail later in the chapter but are briefly mentioned here. They included farmers using peer-to-peer learning (including using the Internet as a digital electronic hedge rather than a physical one) (see Section 6.4.2), learning agroecological techniques (such as mob grazing) outside of established courses and education organisations, and that the biggest driver of agricultural change may be through encouraging people to improve their soil using agroecological methods. Other themes include combating farmer isolation using the Internet and social media plus barriers and constraints to agroecological change.

6.4 Hazards, shocks and stressors

6.4.1 Climate change and weather

Eight of the interviewees, plus various members of the group interview discussed climate change and the weather, and what they were doing to mitigate against climate change. Some were working to sequester carbon, by reducing the amount of tillage, if not completely going non-till, whilst others had their land in permanent pasture:

> "and a lot of it has probably never been ploughed. It's incredibly steep and that means, it's not only got probably good soil structure, in so much as a clay soil can have but it's also probably quite an extraordinary carbon sink so I think it you know, it's doing a very good job and we wouldn't dream of ploughing it up anyway." (Farmer AC, South-West, 2015)

Others wanted to move beyond fossil fuels, using renewables, as mentioned below in the technology Section 6.5.3, whilst others adapted to warmer winters. One farmer interviewed explained how they had adapted: instead of bringing their animals in from the fields once November and December arrived, they moved them back to a field that had already been grazed:

> "Well that's it, in terms of planning grazing, we don't have, we either have a dormant season, or we have a semi dormant season. And so planning for that.... So for example this year, what I grazed in November and December, I actually ended up going back to as it had grown so much" (Farmer RH, Midlands, 2016).

Finally, eight interviewees and two of the group interview participants were working with the unpredictable weather and trying to adapt to the unpredictability to remain resilient to it. Farmer A's perspective below sums up the struggle that those ten participating farmers said they experienced every year.

> "I think we have a more unpredictable climate, I've been here 30 years nearly, and we definitely have wetter winters and we have more high intensity events, the rain that we had last week was very intense, a lot of rain over a very short period of time. But six weeks before that we had quite a dry period, I haven't got records going back 30 years, but my impression is that it is more /less predictable, and more high intensity events, ... We used to get more frost days and more snow days in the winters and we have less of that now. In the summer, it seems to be more damp days, so hay making has become even more of an issue because we don't get, you can't count on a long spell, or even a week of dry weather, where you could dry your crops." (Farmer A, North-East, 2015).

6.4.2 Financial stresses

The majority of the individual interview conversations did not include discussions over financial stresses affecting their farms. However, five did refer to issues where finances had caused difficulties or hazards to themselves or their peers. Two indicated that some of their peers lacked business plans and others lacked business skills to enable them to survive financial difficulties on their farms. Others, during their conversation, mentioned how they had suffered financial struggles and that subsidies from the government had enabled them to keep farming, and in some circumstances, grants enabled them to install new technology which reduced their energy consumption. The participants of the group interview discussed the impact of the CAP and whether the forthcoming European Union (EU) vote would influence farmers getting CAP subsidies. One individual interviewee pointed out the issues that farmers have with the low costs of their goods, combined with the high costs of farm inputs (such as seeds, or fertilisers).

> "all of us even the good farmers today are under really severe financial constraints because of commodity prices and so on and therefore business as usual is really not an option." (Farmer HW, South-West, 2016)

6.4.3 Other hazards, shocks and stressors

Other issues that affected a farmer's assets were related to health: the health of the farmers and their families, the health of their animals, and the health of their land, water and farm environments. Of those interviewed, five mentioned issues related to health influencing their farms and assets. One farmer commenting on hazards spoke about the pollution in his local river, which could affect the health of his cattle, and his crops, as well as the general human population.

> "its horrifying really, cause people don't realise, we're all drinking slug pellets, alright they're diluted, and… they are still finding banned pesticides in this river, so who's put them in, who's doing something about it? The answer is nobody's doing anything about it..." (Farmer GB, Midlands, 2015)

Three were highly aware of the impact on their farm if they were to physically hurt themselves. Two were particularly worried about the impact of moving fences regularly for mob grazing (which is discussed in Section 6.5.1) their cattle, with one going as far as to state:

> "that means that there's a lot of fencing stakes, that was a lot of stress on my back carrying those, and I'm just thinking to myself how sustainable is this?" (Farmer RH, Midlands, 2016).

Another (who had mentioned that same topic during the Phase 1 survey) was concerned about the wet weather on their livestock:

> "It's much healthier for animals to be dry and cold than wet and warm. So I think that I probably mentioned how we've had also very uncharacteristic illness." (Farmer AC, South-West, 2015)

At the group interview, the participants raised the issue of antibiotic use becoming a big issue with antibiotic resistance, and mentioned how intensively produced food could be harmful. However, they did not see either of these issues as hazards to farming. Two of the farmers individually interviewed did feel that antibiotic resistance was a stress if not a hazard to the human population "I think one that probably is a ticking time bomb is antibiotic resistance, we not inventing new antibiotics and were abusing the ones that we already have" (Farmer GB, Midlands, 2015). Therefore, as discussed with two of the individual interviewees, to farm sustainably, farmers needed to include using fewer antibiotics, and consider other alternatives, as excess use of antibiotics in animals can affect "the sustainability of our health system" (Farmer ED, South-East, 2015).

6.5 Learning, sharing knowledge, building assets and gaining resources

Based on an understanding from attending soil and holistic management workshops in 2015, and from chatting to those present, farmers (including growers) attend workshops, some of which have funding to enable reduced cost places for farmers, but others are full price, and all participants are asked to complete a feedback form at the end of the session. The attendees have opportunities to talk to each other and the trainer during the workshop, and build up networking links, which could then be used to correspond with each other after the event. There is also the opportunity to communicate on Facebook, and all participants are sent the presentation slides for future reference. Farmers and growers come away from the workshops with the knowledge to change their farming techniques in order to improve their soil, crops and their businesses.

6.5.1 Phase 2 farmers learning techniques that they had not yet used on their farm.

From the Phase 2 data collection, it became evident that farmers learned new techniques, (which were not necessarily agroecological techniques, they could just be climate-resilient or sustainable techniques), used by their farmer neighbours at local meetings, by chatting during visits to the pub and looking over hedges between each other's fields. One farmer interviewed was using agroecological techniques learnt at a RegenAG course (RegenAG UK 2013) and lived in the north of the country, but was surrounded by conventional farmers. The closest agroecological farmer using those same methods was also on his own, living and farming in the Midlands. Figure 6-1 showed the locations of those interviewed and the relative distances between some of them[76].

Interviewing farmers near Scotland and near Cornwall revealed that farmers who were unable to visit other people overcame the distance between practitioners, using alternative methods of knowledge sharing. This has spontaneously evolved with farmers at opposite ends of the country, so that they were now able to chat about their successes, and difficulties in implementing new farming techniques such as mob grazing, through the Internet, web forums, emails, YouTube and social media. They appeared to have transformed the traditional hedge to a *digital electronic hedge*, over which they shared knowledge online.

> "So what we learn online from other people or visiting other people, we can apply to our context and take bits from here and there" (Farmer RH, Midlands, 2016).

Farmers can gain advice about a new technique from other famers who are also practicing that technique. One example of this that is very successful is the PFLA, of which six of the interviewees were part. The PFLA, who were briefly mentioned in Chapter 5, all keep their cattle or sheep out on pasture land for as many months in a year as possible, and feed them hay from their own fields when it gets too cold or too wet to stay outside. Ten of the individual interview participants were applying mob grazing techniques (which were initially explained in Chapter 2 and in more detail below 6.5.1) and any farmer in the PFLA can discuss and seek advice on new agroecological techniques from other members on the online Members' Forum (PFLA 2015a). As the Google group is for members only, not only do they feel free to occasionally ask basic questions, but they are also not spammed, which other forums may be subjected to.

> "Because there varies a lot of, almost every day there's somebody says something, and actually is very constructive a lot of the time, it is not just sort of senseless nonsense…." (Farmer EM, South-East, 2015)

[76] Two of the interviewees in the Midlands were close together geographically so they appear as one dot on the map.

It is worth considering that the digital electronic hedge could open up the possibility that new ideas could be fed to a farmer in the north, from other parts of the country, which could then challenge existing knowledge in that farmer's local area.

Thus, sharing of farmer knowledge over a hedge is no longer just physically between two fields, but instead, via the electronic hedge of the Internet, it virtually spans the country, allowing one farmer in Northumberland to talk to another farmer in Cornwall and view their techniques. It enables farmers to move beyond the conventional farming in their area, beyond the existing learning and practices in that farmer's local area, and to be supported in creating change that is invaluable in improving the quality of soil, animal health, and their own livelihoods.

6.5.2 Peer-to-peer learning

Farmers interviewed were often keen to learn the successful techniques through the list mentioned at the beginning of 6.5.1[77] and through farm walks[78] "with a group of other farmers where you pick each other's brains and bounce ideas off each other… that's been there since time began" (Farmer B, East, 2015).

Linking the last section regarding the electronic hedge and the next section of learning outside of workshops and courses, peer-to-peer learning includes farmers sharing knowledge, experience and learning over the Internet (through video, forums and social media, using the electronic hedge), and at events and courses (where breakout sessions allow farmers to chat and network with each other).

> "I had one person who said to me, she found it more interesting talking to the other people who attended the course who were farmers, than the trainer" (Grower, Midlands, 2015).

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[77] Which states: 'farmers learned new techniques used by their farmer neighbours at local meetings, by chatting during visits to the pub and looking over hedges between each other's fields'

[78] Farm walks can be seen as more traditional than using the Internet and social media to share techniques and practices.

Nine of the individual interviewees and two of the group interviewees preferred their farming peers to share their field experience at workshops, rather than listening to the knowledge gained from books or academic experience of those who led courses.

> "If it's someone who is doing it, or has done it on their farm, it is far more relevant, than people who have learnt the theory and are just telling us. Because when the farmers ask them specific questions, they can't actually answer them because they've never done it themselves" (Farmer EM, South-East, 2015).

Other methods to share learning included setting up a group with like-minded interests such as "people who either own or want to create more diverse meadows" (Farmer AC, South-West, 2015) which gained more than forty members in a few months, enabling them to share seeds, ideas and experience in an informal setting. Some farmers found that they were the first to learn a technique and then ended up providing the specialist advice to their neighbours and other farms free

> "as we've often found that we are ahead of the game, so we're learning as we are going along. We are then in the position to provide help and knowledge to others in a bizarre way!" (Farmer B, East, 2015).

As some courses were felt to be too expensive, or too far to travel, peer-to-peer learning, and learning outside of formal courses was vital for farmers to continue to learn new conventional or agroecological techniques. This is discussed further in 6.6.2.

6.5.3 Learning outside of courses and organisations

Following on from the last section, those interviewed indicated that farmers were learning agroecological techniques outside of courses and organisations, instead from books, word of mouth, and the Internet, yet gaining similar results to those attending courses such as those offered by RegenAG.

> "There was a chap down there, who had, purely from videos on YouTube of American videos mainly, who had done that…. But there are a lot of people out there, who are not tied into the RegenAG communities, who are not tied into holistic management things, they're just taking on these techniques. They probably might not even be interested in getting too

> involved with any of that, they're just interested in saving money and what works." (Farmer RH, Midlands, 2016)

Furthermore, other farmers were reading books such as Graham Harvey's *The Carbon Fields* (2008) and adapting their farming styles as a result. "Locally, I have met two other farmers in Kent that are now doing mob grazing, they found it just through videos on YouTube and reading…" (Farmer PV, South-East, 2015).

Why did some farmers learn outside of courses? Some reasons given by the interviewees included feeling like they knew their land best

> "cause once you understand, sort of the principles behind it, you don't need to go on a course, you just need to know your land and where your problems are" (Grower, Midlands, 2015),

or because they preferred to learn by reading.

> "So I think that what we've done, we've done following our own reading and you know, it's not rocket science is it?... To be honest, I think if you want to do it, you probably don't need a course to do it with" (Farmer AC, South-West, 2015).

As shown in Section 6.4.2, two of the individual interviewees found that there were no courses on the topic of interest (Farmer AC, South-West, and Farmer GB, Midlands, both 2015), whilst another found he wished to learn before he attended a course, to make sure he knew what was being discussed, and then use the course to embed the knowledge.

> "So, I already knew, I'd actually read a lot of material, and there was nothing from my perspective to argue about, I knew that this was the thing to do. So, I suppose I went on the course really to kick myself into moving forwards with it and start to really go through the process and force myself to do the written planning really. And also really to just enforce the ideas that I had read about" (Farmer HS, South-West, 2015).

Other farmers interviewed found that their learning style did not suit courses, instead learning through discussions with their peers and practical experience were better.

6.5.4 Learning in different ways

As shown in the previous sections, informal structures of learning on farms were well practiced[79]. It would also appear that many farmers mainly learned through doing an activity, hearing about an activity or seeing a technique being used[80], so farm walks are a good way for farmers to experience all three in one session.

> "I learn more by visiting farms and hearing farmers talk to each other, and saying, discussing something through. Personally, that's how it works for me, and I've learnt farm more of the practical techniques from doing that than, you know reading books and things." (Grower, Midlands, 2015)

Furthermore, IT technology such as creating and watching videos, typing comments on a discussion forum and reading answers, or listening to podcasts and viewing conferences via live web-streaming, has enabled the interviewees to develop their skills and knowledge of using agroecological techniques[81]. It has enabled their skill development to occur in the manner best suited to their method of learning without leaving their farm, or spend lots of money on a training course[82].

> "Yep, I think there was quite a discussion going, I think I posted the question about running out of grass and not having much silage and then there was a huge slate of replies from lots of other people. There's been a couple of questions I posted on it, they have resulted in an awful lot of discussion. I have found it a really useful tool, the pasture fed Google group." (Farmer PV, South-East, 2015)

Other farmers that were interviewed may have found a course useful, but were also very happy to research a technique themselves, using literature beyond that provided

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[79] Furthermore, through attending farm walks organised by Warwickshire Rural Hub (Sheppard 2012, Schmidt and Wolfe 2009, Dockerty et al. 2006, 2005, Climate Outreach 2016, Nicholson-Cole 2005, Corner et al. 2016) it became apparent that the traditional learning styles were still effective in encouraging change and learning.

[80] These are known as kinaesthetic, visual and aural learning styles, but as this thesis did not assess the learning styles of the interviewees, this section is more about the different ways the farmers found answers to problems, and learnt new techniques.

[81] Furthermore, over the course of the data collection, it became apparent that many farmers respond to observation of agroecological techniques when they showed clear signs of success. This has been explored in books and journal articles (2016) as an alternative way to create change that was not explored in detail during this thesis, but would be a useful technique for future research.

[82] This is discussed further in the Burbi and Hartless Rose conference paper (Richmond 2011) in Appendix 11.

in the farming magazines, particularly if the topic of interest had not become adapted by organisations for courses.

> “So it's been wading through quite a lot of research, and often that research has been in academic journals where you have to pay a vast amount to get the articles, so you have to beg/borrow articles from friends at University or find the only ones that are actually open source and just try to piece it all together. But I think that that area is just about beginning to be picked up by organisations that will give presentations to farmers.” (Farmer C, East, 2015).

6.5.5 Speed of learning and the pace of agricultural change

One area that emerged from the interviews was about technology speeding up learning, creating immediateness:

> “Of course, the other thing nowadays is that everything is so immediate. Social media…If you want to know what you saw on Twitter this morning, and its now midday, ‘where has that gone’ or Facebook, you are really struggling to find it as there is so much stuff coming since then,… and because everyone is so conditioned to the fact that it is not there, it's gone and we forgot about that, and you're moving on and because life (in most places) is at such a pace, there's so much coming up that it probably takes a while you to say ‘oh yeah I remember’, but you can't remember exactly what it was.” (Farmer GB, Midlands, 2015)

However, at the same time some commented obliquely on how agricultural society is changing incredibly slowly.

> “So the interesting thing about the farm walk with Joel the other day was that it wasn’t in any way organic, this was an AHDB monitor farm.… The really interesting thing was how you had an audience of farmers and there must have been 40 there, maybe 50 even, which is really good, sitting down listening to a chap talk about mycorrhizal fungi. You know you wouldn’t have even got that, probably even five years ago, so that in itself (maybe they didn’t know they were coming to listen to a chap talk about mycorrhizal fungi), that in itself is interesting….” (Farmer HW, South-West, 2016)

He went on to discuss that even young farmers were not necessarily changing to consider agroecological methods and that could possibly be due to inherited knowledge from family, or educational knowledge from formal establishments.

> "I think things are changing, I don't want to paint to gloomy a picture, people are changing and the agricultural world as I think you probably know, things change slowly. And it's slightly disappointing when I had this conversation with a man of 30, so he's a young man relatively speaking, and I would have expected him to be much more interested in other approaches." (Farmer HW, South-West, 2016)

At the group interview, whilst the majority of education and research Ketso leaves[83] were positive (see Figure 6-2 below), a couple of points specifically referred to education, knowledge and learning running significantly behind that of the practitioners who took part in the group interview.

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure 6-3 showing the Education section of the group interview's discussions (see footnote 60 for explanation to the leaves

Green leaves (weaknesses) included lack of public understanding, a scarcity of evidence and a shortage of long-term studies and precedents in UK research, as well as the agricultural mainstream remaining conservative and to some extent lacking in agroecological skills.

[83] The leaf colours relate to: Strengths (brown leaves), Weaknesses (green leaves), Opportunities (grey/blue leaves) and Threats (yellow leaves), relating to opportunities to embed RegenAG in the UK.

6.6 Agroecological and sustainable farming and climate-resilient farming techniques

6.6.1 Grazing management and mob grazing

Mob grazing (which was explained in Chapter 2) has been discussed alongside grazing management over the course of 2016 in the PFLA Google group, where the discussion revolved around how different or similar mob grazing was to the traditional rotational or paddock grazing[84] which has been around for centuries (PFLA 2015b).

> "There's a thread on the Pasture-Fed Livestock Association thing where someone had written rotational grazing is nothing new that's quite right, rotational grazing is been around for a long time, but about trying to get that right for your land and climate." (Farmer RH, Midlands, 2016)

Furthermore, there is a saying amongst farmers that was heard repeated frequently when attending Farm Walks and on RegenAG UK workshops that stated, 'Sheep should never hear the church bell twice in the same field'[85]. Or as another farmer put it "I tried to give them a fresh bit every day" (Farmer PV, South-East, 2015)

Those interviewed who used mob grazing (or the similar yet less intensive, 'low intensity grazing') found their grass and soil improved "We divided the fields up and we move the animals from small paddocks into other small paddocks every week…. we've seen a tremendous difference in land. Really, really good" (Farmer EM, South-East, 2015). They also found the animals in better health and "less foot problems, higher milk yield" (Farmer MC, South-West, 2015). "That's one good thing about mob

[84] To some extent, mob grazing just rotates far more intensely than the original rotational grazing.
[85] i.e. assuming the church bell only rings on a Sunday, farmers would move their sheep at least once a week

grazing, they keep moving them on so they don't get the build-up" [of worms and other parasites] (Farmer GB, Midlands, 2015).

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure 6-4 Mob grazing a flerd into a new section of the field using mobile electric fences

Some farmers had even started mixing their cattle with sheep in the sections. Referred to as 'flerds' (both a flock of sheep and herd of cattle, see Figure 6-3), discussions on the PFLA message board suggest that grazing both together enabled better weed control, more animals grazing on the same land at the same time (better stocking rate) and better quality of grass (PFLA 2015b).

However, for some of the interviewees these techniques (including mob grazing) were fairly new, so they are also learning as they go along. One farmer who was interviewed explained about the problems he was having with creating the small paddocks and keeping the sheep contained within the area.

> "It's good, but it's very time-consuming, was my initial experience.... It's just moving fences actually, because of cows it's very easy as you just have one strand and they're very scared of electric, but with sheep some of them are not scared of electric and you need to put three strands up as

> well…. The milk sheep are very greedy and always keen to get to the other side of the fence and they worked out that the corner post is a slight rise in the wire so they know if they sprint at the corner post and duck their heads down they can get out… I think I might go with netting next year but that's even more time consuming to put up, but is much more effective in terms of containing the sheep." (Farmer HS, South-West, 2015)

Some of those interviewed struggled to divide their land into pastures due to footpaths across the land (Farmer ED and Farmer PV, both South-East, 2015) whilst others struggled with supplying water to each paddock. However, solutions have been found and shared with peers, neighbours and others who are interested.

> "yes, well at a farm in Kent, they have a micro-trough, which is like a little water drinker, it is just plastic on a spike that you stick into the ground, and you can drag it around with you to the different areas. There is no reservoir of water in it, is just like the drinkers you get in stables, and so the cattle have to push a plate to get the water…. I can just pull it back to go to wherever I need it to. And then when we move to a new field I just take it with the quad, drag it" (Farmer PV, South-East, 2015).

Many of those interviewed who were using grazing techniques such as mob grazing were also struggling to work out how to graze their animals throughout the winter especially when there had been excess rain throughout the summer, impacting on their hay crop. Some wondered when they should bring them in and feed them with the hay and silage grown on the farm, and if so, was there enough to last throughout the winter.

Another issue mentioned in many of the interviews with livestock farmers that can be both a problem and a benefit, is managing the manure of the animals. It contains valuable nutrients which can enrich the soil, but it is far more useful once its been broken down and composted even through using "lazy composting" or "dump and wait" (Farmer HW, South-West, 2016). The most traditional method to turn it into compost involves "taking the dung out of the sheds in the spring and putting it in a heap in a field rather than spreading it straight away" (Farmer AC, South-West, 2015).

Others used it on their horticulture[86] or on their hay fields and relied on the animals to spread the manure on the fields they were grazing on (Farmer AC, South-West, 2015).

Those farming livestock automatically had to consider the quality of grass (Farmer MC, South-West, 2015) and manage it; "By grass I also included all those other nice things you put into modern leys, all the herbs and things, but how you manage them and the ability of those plants to interact with the soil" (Farmer HW, South-West, 2016). However, some of the arable farmers found grass (either as a rotation, or for renting to livestock farmers) not only improved their soil quality (which affected their yield and quality of the crops), but also reduced flooding and enabled the land to cope better with excess and reduced rainfall (Farmer B, East, 2015).

6.6.2 Soil –The motivating theme that encourages all farmers to begin to farm more agroecologically?

Whilst most of those interviewed who were affiliated to the Organic, Permaculture or the PFLA movements were already farming using agroecological methods and were actively working to improve their soil health and quality, of the two conventional farmers interviewed who mentioned soil health and quality, both were arable. The one conventional farmer who was dairy and beef did not specifically discuss soil, but referred to the quality of his grass, and how it created a higher milk yield and reduced the mud and cattle feet problems. After considering this, one of the later interviewees was asked the question why he thought conventional arable farmers (who actively need healthy soil for a good yield) were ahead of the learning curve than those farming with livestock or dairy. His response was:

> "Because the arable people are very much more willing to listen to something different, because quite often a change to the system for arable, you know you might gain or lose a little bit in one year yet, but there's always next year…. It's a big change to change the whole of your herd. I think that's probably why the arable guys are more innovative and willing to take risks in some senses." (Farmer RH, Midlands 2016)

[86] (Farmer GB, Midlands, 2015 and Grower, South-East, 2016)

A farm soil advisor who had been praising the PFLA of making waves with their farming techniques, gave a balanced argument noting:

> "I got rightly brought down to earth the other day by the head of one large company, I said 'it's really good, we're seeing lots more soils, farmers are making a difference' and he looked at me and said, 'you know, of course they are. The guys that you are dealing with are probably the top 2% of farmers so you're making waves but you're making waves in 2%' and I was like, you're so right if you actually think about it…. You're dealing with people that are changing already and they're looking at it and you know, how many farms do I go on and they don't even measure yield?" (Advisor A, 2016).

However, many of the farmers interviewed attended workshops related to soil. When attending the first RegenAG UK Soil workshop in 2015, of the fifty attendees, many were conventional arable and during the interview with the farm advisor, he stated:

> "I think what we're seeing, we're seeing business grow on the soil side is because quite a lot of it, people have suddenly realised that… they're not as sustainable as they were. i.e. that their fixed costs and variable costs are going up and their yields aren't. So, there's a big question, how can that be? And then you start looking at nutrient efficiency. They look at what they're doing to soils. 'Blimey, we're spending a lot of money doing this, whereas Grandad didn't' because they had the organic matter if you like or the soil structure was more careful so there's certainly a, what's the word you use for this, a commercial element to it but there's also a sort of ...Pragmatic, yep a pragmatic view" (Advisor A, 2016).

One interviewee pointed out that it is hard to teach by example regarding soil organic matter on courses (Farmer HW, South-West, 2016). However, as shown in Figure 6-5 below, on farm walks you can take a spade and dig up the soil to show the difference. These farm walks are being attended by those farming from conventional, to agroecological.

Others are taking advantage of farmers who are ahead of them to seek advice. On the farm walk where Figure 6-5 was taken, one farmer (who had done a Nuffield Farming Scholarship on soil carbon(Havard 2015)) attended and was sharing his knowledge and experience with those farmers on the walk. Everyone on the walk was contributing information to the farmer whose land was being shown, about how he could improve his soil; he learnt as much as those who attended did.

Figure 6-5 Soil structure of top soil after three years of grass/clover ley

Farmer HW was also getting advice, using another farmer:

> "It's just that she's interesting and so far is that she started her life as an animal nutritionist, did a Nuffield scholarship, and when she was abroad she sort of the massing moment when she realised hang on the health of the cow is all about what they're eating, and the reason is all about the soil.… And now she's actually gone from an animal nutritionist into actually a soil scientist" (Farmer HW, South-West, 2016).

Sending soil to labs for analysis was a topic that cropped up during the farm walk above, and from two of the interviewees, in that when the farmers sent their soil off to labs, they discovered vastly different results, which could be off-putting to any farmers who were not used to lab results. However, both interviewees pointed out that as long as the farmer kept using the same lab, they would discover if their soil carbon and nutrients were increasing as it was more that the interpretation of the results confused rather than the figures being wrong (Farmer HW, South-West, and Advisor A, both 2016).

Another issue that interviewees raised was that due to the economy and low incomes for arable crops, that it might benefit some farmers to grow green manures and cover crops. That would improve their soil structure, carbon and nutrients, so that once the price of arable increased, they would get better yields from their arable crops, as introducing cover crops and green manures in rotation, or setting aside permanent pasture will improve their soil structure (Farmer AC 2015 and HW 2016, both South-West, Farmer RH, Midlands, 2016). Cover crops and green manures also improve the nutrients in the soil.

> "Obviously we try to use much more in the way of nitrogen fixing clovers and other crops. When we still did arable, red clover produced a fantastic amount of nitrogen nutrients used as a cover crop on a rotation. So would grow sort of clover ley and leave for three years and then plough it in and then grow your arable crops, and it was very very effective. We didn't use anything else, and it had good yields" (Farmer GB, Midlands, 2015).

As mentioned at the beginning of this section, some of the conventional farmers interviewed, as well as some of the organic and PFLA farmers have begun using minimum tillage, direct drilling and Keyline to improve their soil. As discussed concerning the respondents in Chapter 5, some of the farmers interviewed had begun to move towards using minimum to no tillage on their arable land.

> "I think the plan had been to moving towards no till, with cover crops. And I think there's a general expectation that switching to no till, you will get a yield dip in the initial years. I thought it was important to go through strip tillage to start with, which is a slightly higher disturbance way of direct drilling. So, at the moment we are direct drilling but through strip tillage about half the farm. So yeah about half the farm which probably about a thousand acres in direct drills, but that is quite a long way away from zero tillage with cover crops and a lot more diverse rotations" (Farmer C, East, 2015)

One farmer who attended a Regenerative Agriculture course, had gone on to include videos of his successful and less successful implementation of holistic management and regenerative agriculture methods on his farm in Gloucestershire (Havard 2015). He then worked on Keyline ploughing which, using sub-soiling techniques, breaks up the soil to 15 centimetres depth on contours around the slope of the field. This improved the drainage across his compacted and waterlogged field, and improved the grass quality over the three months since he started (Firbank et al. 2013, Chel and Kaushik 2011, Lal 2015).

Another interviewee who started experimenting with Keyline to see if it would benefit their land stated:

> "The other thing I was thinking of doing is a little bit of Keyline ploughing, basically off the back of Rob's video. I think I got one compacted field and I'll probably basically just do almost exactly what he did so manure it, I've got a subsoiler so I'll mark out the contours and subsoil in lines around the field and see if that has a positive effect" (Farmer HS, South-West, 2015).

However, the first farmer, in his interview reflected that whilst it worked on his compacted soil, there were negative elements to using the Keyline technique as:

> "running [a] metal shank right across the pasture in line, so you're basically if you got any fungal interactions and fungal hyphae traveling any long distances, you've just chopped it up to spaghetti. So that's potentially not good." (Farmer RH, Midlands, 2016).

Of those who were interviewed and talked about soil, three had noticed improvements, one with increased worms "But just by the last time I dug holes in that field it was looking a lot better, lots of worms! It's also adding an awful lot of organic matter into the soil" (Farmer PV, South-East, 2015). One farmer with improved water retention "I think with water, where we saw the benefits were on a bank, so we noticed an area which used to dry out quite quickly, and didn't grow much grass because it was much dryer, we noticed that it evened with the rest of the pasture, and solved that issue" (Farmer RH, Midlands, 2016). Whilst another farmer found less compaction and improved top soil and root matter:

"I think you can see an increased load bearing capacity of the soil after only one year of direct drilling and that obviously helps with reduced compaction…. I think you can definitely notice increased root matter in the top 10 cm, some wider benefits I think you can see is more wildlife in the cover crops than on the bare ploughed soil" (Farmer C, East, 2015).

6.6.3 Reducing use of machinery and using renewable or more efficient technology

This theme consists of those who were reducing their use of machinery, "some of the guys I'm working with, have actually bought smaller tractors in the past two years and that's unheard of." (Advisor A, 2016) and those who like a farmer in the South West who is using machinery to enable him to farm more efficiently and sustainably. "I'm not sure where I would have learnt, but I put in a variable speed vacuum pump, and things like that. And heat exchanger and bolt tank compressors, so you get hot water all the time." (Farmer MC, South-West 2015). Other farmers were using renewable energy to power their lighting, or other electric equipment or are reverting to scything (if they have a small farm) rather than combining:

"I went to a scything course, it's a bit old fashioned, and that's another way of minimising our carbon output, because using your body rather than a piece of machinery. Apparently, a lot Natural England and a lot of wildlife trusts are starting to use scythes instead of strimmers and things…." (Farmer ED, South-East, 2015)

One interviewee pointed out a group which had set up a website to promote the sharing of machinery.

"So, there's been like this farm hack thing that's been happening…this one group of people who are trying to get this mobile trailer up and running with like welding equipment stuff, so they can go around to different places... weld or make new things or do workshops and stuff…" (Grower, Midlands, 2015).

There were also discussions from some farmers about costs of replacing machinery from the old farming system (e.g. a plough) with machinery for the new system.

"You might have problems such as increasing machinery costs when you actually transition across towards the new system. You might not be able

> to sell all the machinery at the price you want and buy new drill so you will end up having an overlap of two systems which would put your costs up in the interim" (Farmer C, East, 2015).

As considered in Section 6.4, other farmers have started using the Internet to record, share and discuss their experiences of farming using alternative techniques including the agroecological ones mentioned above. This also links with farmers using smart phones to control their tractors, yield mapping the crops to see what is fertile and what needs more nutrients (Farmer GB, Midlands, 2015). Some farmers "had introduced GPS on the tractors, so instead of saying well that's a straight line I will go along there, or going the combine way and overdoing it, or under doing it so you either miss a bit or you do one bit twice, it does it exactly. The GPS steers the tractor" (Farmer GB, Midlands, 2015). This precision farming could be considered potentially more environmentally friendly or agroecological due to the technology reducing the amount of fertilisers used (so less is leached into rivers, or potentially converting to N_2O, or reducing tractor fuel used. However it also has cost benefits due to lower usage of products such as fertiliser or seeds (Wyn Jones 2013).

6.7 Drivers and barriers

Many of the topics related to barriers constrained those farmers interviewed from accessing resources, knowledge or techniques. However, for some of the interviewees when they experienced a barrier or constraint, they found ways to get around it; thus, the barrier in turn created a driver to change. This is most noticeable in the finance section (6.6.2 below), although for those farmers who are determined, the other barriers in this section can provide opportunity.

6.7.1 Isolation and the Internet

Farmers in remote areas of Northumberland have benefited from Internet communication as it has enabled them to communicate instantly with farmers in Cornwall. Previously, they felt isolated as they were using significantly different agroecological farming techniques from their conventional neighbours. During the deep snow in 2013, one farmer in a remote part of Snowdonia was tweeting about his flock of sheep (*BBC One - The Farmer and the Food Chain* 2015) and in the years since, he has gone on to make BBC documentaries about rural life, food and farming (Barnes et al. 2010).

Using electronic digital communication / social media, has not only enabled farmers to share and learn with other interested farmers, who were geographically disparate, but also has helped those farmers in more isolated areas to feel connected to a networked and connected community of farmers who all employ agroecological techniques.

> "But often I think you a little bit on your own and I think that is where, I mentioned the farming forum, I think that is a way of bringing together some of the most innovative farmers and I think well beyond the mainstream consciousness of farmers in general." (Farmer C, East, 2015)

Using the different media available on the Internet, from social media, to videos, web cameras and Internet video and voice call, enabled electronic peer-to-peer learning and could also be a way to mentor another farmer who is further behind. Potentially, it could dispel isolation for those farming substantially differently to their local neighbours.

> "…and to have somebody there to say, 'actually have you thought about doing this?' because obviously, there is no one in my immediate surroundings who does any of this. We are really in a very traditional farming area, so to have somebody who could, I don't know just lean over the gate, or be at the end of the phone and say, 'you are doing this, but how about doing that?' That would be really useful, it's a sort of mentoring role really." (Farmer A, North-East, 2015)

At present, most of the farmers applying RegenAG practices were on a similar level so mentoring was a little hard. However, as more farmers learned about agroecological techniques, there were other farmers who were a little ahead (even if just by one year) who could therefore share their experiences with those who had just started. YouTube videos were another way to help share learning. However, those at the group interview felt that the long distance between the practitioners was a threat to embedding RegenAG in the UK.

6.7.2 Finances, economics and resources

Finances, economics and resources were a theme that has appeared throughout the literature, as well as in both the Phase 1 and Phase 2 research, and could either promote change to a farmer (as a driver), or prevent it, depending on the farmer and the circumstance.

One farmer had used grants as drivers to install renewable energy that had then become one of the biggest generators for income on his farm.

> “the vast majority comes in through the feed in tariff…, we export the lion [sic] share of what we produce, we only use very little electricity on our farm anyway,… just because there are relatively few occasions where we actually need electricity. So, we probably export 99 1/2% of what we produce anyway. So the feed in tariff is the most important element, followed by the export value of electricity.” (Farmer B, East, 2015)

Another was receiving government funding to enabling them to keep permanent pasture and wildlife friendly fields (Farmer AC, South-West, 2015), whilst other farmers were diversifying by working outside of their farms (Farmer ED, South-East, 2015 and Farmer A, North-East, 2015). One of the growers was working to encourage community-supported agriculture (CSA) to be self-sustainable outside of grants and improve their business sense.

> “The other thing that (for me) that's really changed is running businesses, is how neglected the business side is, I mean, you know, growing is stressful and hard, but most people completely don't think about the business side at all, and most, I would say, the majority of permaculture projects I don't really know any that are self sustaining. You know, I mean they all need grants and God knows what else…..” (Grower, Midlands, 2015)

As mentioned above, at the group interview for RegenAG members, comments about threats and weaknesses outweighed those about strengths and opportunities[87]. Considering the threats (or barriers to change) in Figure 6-6, the majority of them reflected the anti-capitalist left-wing viewpoints of those who attended (the threats being named as: big business / corporations holds status quo and military-industrial complex). If those points were counted as one rather than the three-five points shown above, then the potential drivers could be seen as having greater significance to the attendees than those that might be seen as barriers.

Figure 6-6 Economics categories of the group interview's discussion

Another farmer was looking beyond his farm and at the UK agricultural system in general and applying his experience of cattle on pastureland to other farmers, and improving incomes stating:

> "But for sheep in our climate, I think that's an excellent system, And I'm actually thinking in our climate that might be the most profitable, because

[87] Strengths (brown leaves), Weaknesses (green leaves), Opportunities (grey/blue leaves) and Threats (yellow leaves). The weaknesses and threats could be considered as barriers and the strengths as drivers with opportunities possibly also reflecting drivers in some circumstances.

> it’s easier for them to be carried on the turf over the winter than cattle be carried on turf” (Farmer RH, Midlands, 2016).

However, there were financial barriers and for some it meant that they rarely attended a workshop or course. The reasoning was varied. Some it was due to the cost of the course “Also, they look to me to be quite expensive” (Farmer B, East, 2015). Others, the distance (this was the highest reason why among the interviewees) “but a lot of the courses that RegenAG run are quite a long way away and it really has to spark my interest to me to want to travel a long way away” (Farmer PV, South-East, 2015). A few of the interviewees could not afford to take time way from the farm “part of the problem is getting away, the logistics of getting to Bristol in January” (Farmer GB, Midlands, 2015). The last barrier to attending a course, was that the costs and time of travel on top of the course itself made it too expensive (Farmer B, East, 2015).

As mentioned in Section 6.6.2, farmers were finding “that they’re not as sustainable as they were. I.e. that their fixed costs and variable costs are going up and their yields aren’t” (Advisor A, 2016). Whilst: “the prices that we are getting for arable crops are very low at the moment and we all think they should be a lot higher, but there is no guarantee that they are going to go up even if we think they should” (Farmer B, East, 2015).

Furthermore, in 6.6.3 the costs to switch to a new agroecological technique might reduce with lower farm labour costs (although that would impact on the livelihoods of those contracting and labouring). However, the costs might increase with the new farm technology.

> It's quite a big system change if you suddenly sell all of your machinery and buy a no till drill, you would have issues such as reduced labour input, and what do you do with people that you employed if you realise you don't need as much labour? As that would be a big impediment and you might think wait until some my employees retire and then slowly phase it in” Farmer C, East, 2015).

Others interviewed found that to fully embrace the new techniques required either a large outlay to buy the resources “Molasses is probably the most expensive component of the whole mix. It’s one of the major ingredients to help give the bacterial microbes energy and it’s quite expensive. It’s about thirty pounds for twenty litres” (Grower, South-East, 2016). Or, those interviewed found they needed to plan a slow process of change “as I can’t really afford to go out and buy 1000 plants in one go, so I have to either grow them myself or graft them myself, beg, borrow or steal, so it goes relatively slowly (Farmer A, North-East, 2015). Joining local networks can help with borrowing or sharing seeds or plants between farmers, which those who were part of the CSA found, with extra tomato plants, or pepper plants available for people to take home (Grower, Midlands, 2015).

The other issue which links to the next section, 6.6.3, regards ownership of the farm; some of those interviewed were tenants and found the owners including the local council blocked installing new renewable technology (Farmer MC, South-West, 2015). Farmer C summed up the situation:

> “but for a lot of tenants it's a big problem to have single year tenancies when they are not able to think in terms of a long-term way, as it's much more difficult. I think the other problem if you are a farm manager, is if you have landlords or employers who aren't sympathetic to those long-term aims, who want just to get the best return they can then it might not actually implement it… The landowners or employers of the farm managers, then they might be unhappy if you suddenly have a crop failure, where as actually that might be balanced by an increased yield over the old system the next year” (Farmer C, East, 2015).

6.7.3 Practicalities and lack of uninformed knowledge creating barriers

One farmer interviewed mentioned the confusion over research regarding minimum tillage:

> “There are certain studies, if you look at a couple of meta-studies that show there is no overall effect on it then if there are a number of uncertainties in the back of your mind, that it will hinder adoption because people will be thinking 'well, that might put my yields down'. And again, if you look, there's conflicting research from both sides, or there is conflicting research that is one bit of it” (Farmer C, East, 2015).

Other practicalities included having the labour and physical work to carry through the changes “But I think the trouble with so many things is as farmers have just got busier either because they have got other businesses, or the number of employees has declined” (Farmer B, East, 2015).

Despite these barriers, some did change, yet one interviewee explained that even with regulation to encourage change, some still farmed unsustainably.

> “but there is also undoubtedly some people,… who have been farming for donkeys’ years, who have never kept up to date with anything, and probably don't even know they are banned, and nobody's got around to telling them, or checking up to see if they are using banned substances” (Farmer GB, Midlands, 2015).

As mentioned in Section 6.5.1 above, changing techniques could require knowledge and resources to overcome practical difficulties (such as footpaths or water) “we were encouraged to plan out how we would divide the fields up on paper before we did it all… I didn't do it, I couldn't get my head round it because I got so many footpaths on the farm that is my main problem” (Farmer PV, South-East, 2015). This could also include translating what has been taught in theory at a course, into practice. The other consideration is:

> “in larger farms where you have paid staff, and you rely on other people in other words, you have to take them with you and that can be a real challenge. And that’s the other thing, is not just the knowledge thing, it is actually a different way of thinking. And it’s very challenging (Farmer HW, South-West, 2016).

This leads to the next section regarding sociological and psychological barriers hindering or constraining access to resources and change.

6.7.4 Sociological and psychological barriers to agroecological change

Over the course of the individual and group interviews, it became apparent that a farmer’s beliefs, characteristics, and willingness /capacity to change, alongside any physical and mental health issues, or social / cultural acceptance amongst their peers were strong barriers to achieving change[88]. They could be seen as just as important as the structural or financial barriers that DEFRA's report considers (MacMillan and Benton 2014).

> "There's also the pride element, it's difficult for people, for me I'll admit it, to go and ask for help." (Farmer RH, Midlands, 2016)

> "Also if it requires a lot of new learning and big overhauls of the way you do things than that is a barrier that some people might not want to jump over." (Farmer C, East, 2015)

If a farmer believes they are not ready to host a farm walk to show their agroecological techniques, that can create a barrier to the farmer benefitting from the discussions and advice that evolves throughout the walk, as discussed in 6.5.2. "You got to get to the stage, you know I'm at the stage of trying to make it work, I'm not at the stage of having made it work and want to show other people" (Farmer HW, South-West, 2016*)*.

If conventional farmers are simply not interested, that creates a barrier to considering changing farming techniques, as well as one to accessing resources and techniques that might improve their soil, or animal health.

> "you're going to this guy, a manager, a business manager, all very very busy and he goes, yes I'd love to do that but I've got a harvest to crop and it's really muddy and blah-de-blah and I'm going to degrade my soils but do you know what, I'm not interested" (Advisor A, 2016).

> "But they don't understand, so it is the education process as to how to make people realise, although if they are not interested they won't realise anyway, because they're not receptive" (Farmer GB, Midlands, 2015).

Equally if a farmer learns that by using mob grazing he will improve the health of the cattle, and the grass or soil quality, and his learning develops into a strong belief, then

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[88] This reiterated knowledge gained from the whole PhD experience, from the literature reviewed, to farm walks.

no matter what other family household members may say, that farmer will still choose to implement his learning (interview with Farmer RH, Midlands, 2016). However, in other circumstances, family can cause difficulties and can slow the process of a farmer beginning to use agroecological techniques.

> "One of the big constraints was my family, getting them to accept that we need to change the way we needed to run the farm. They were all like 'we've always done this so why should we change the way we do it'" (Farmer PV, South-East, 2015).

> "One of which is quite a light hilly soil which if I was to choose one which I really would want to use that system on [direct drilling and minimum tillage], it would be that one, but that is farmed by my uncle and I don't think he would be very keen to do that" (Farmer C, West, 2015).

Furthermore, if a farmer is beginning to feel their age and has no one to inherit their farm from them, then making changes that will take time to implement may not seem suitable or appropriate, so they will keep farming in the same manner that they have always farmed. "I mean I'm probably the wrong age, I am going to be 60 next month, and I haven't got any sons or daughters coming on behind me, but if I was 10 years younger I would be far more likely to do it" (Farmer B, East, 2015). Age also influences areas beyond the farm gate, such as markets that stock local farmers' products.

> "Although one has just folded up (what used to be called Country Markets), it just packed up last week because they were all getting older, their clientele was getting older, the health is getting older and the only younger one decided she wants to move to Yorkshire, so that was the end of that" (Farmer GB, Midlands, 2015).

As farming is a very physical job and can at times (when your crops fail, or animals die) be very demoralising, it can also impact on younger farmers and create situations that might encourage them to give up. Those interviewed did not want to give up, but they did experience stress.

> "It's a lot of physical work. You have to be strong and disciplined to kind of actually put it into practice…. I think it's something a lot of people would lose interest in if they were trying to do it themselves because it is quite demanding" (Grower, South-East, 2016).

Another found that they had misjudged their winter feed due to poor weather, and so they were experiencing stress over that winter (Farmer RH, Midlands, 2016).

The participants of the group interview also considered that wellbeing and mental health of those participating in Regenerative agriculture might threaten the spread of knowledge to other farmers.

Based on the interviews, other barriers that can influence a farmer's willingness to change, connect with the confusing research in Section 6.6.3 above, and when that topic was discussed in the latter interviews with Advisor A and Farmer A, they commented on two other issues. One was the careful use of language which would make sense to the farmers "the terminology is a bit off putting for want of a better word, it's almost better to use the objectives and aims, business planning model, which is a bit less scary, but give it a holistic swing if you like" (Farmer A, North-East, 2015). The other was the role of academia "I think one of the resistances is there are too many people practically farming, fed up of people in ivory towers talking to them" (Advisor A, 2016). After discussing the DOFF programme of engaging farmers with research and even developing the topic for research (Cook et al. 2016), he agreed that that might be one way to defeat the 'ivory tower' resistance (Advisor A, 2016) and 'off-putting terminology' (Farmer A, North-East, 2015) and encourage willingness to change. This is discussed more in 7.5.1.

When examining a table of the codes coded with barriers and constraints, whilst finances are the most dominant (coloured in yellow), psychological and sociological barriers (coloured purple) and knowledge and practicalities (coloured blue) are also fairly well represented in the Table 6-1 below (green are geographical barriers and not well represented).

Table 6-1: Showing interviews by number of coding references for constraints and barriers codes

Barriers and constraints or problems implementing	Number of coding references
Time and distance[89]	20
Costs and finances	18
Physical, social or mental	15
Confusing research, language or mistruth	11
Apathy and lack of interest	9
Government negative policies or lack of support	7
Isolation	7
Lack of resources (products or labour)	7
Prior knowledge	6
Difficulties to converting (machinery, time, money, learning)	5
Technology and IT hindering	5
Yield Loss	5
Belief	4
Industrial agri - big business	4
Rented Land and managing land not owned	4
Family	3
Topography and geography	3
Cutting employees	2
Public opinions	2

6.8 Summary

This chapter has used the analytical framework to analyse the results from the Phase 2 individual and group interview. The chapter began by considering the respondents and their assets, an initial analysis and the hazards that impact on a farmer's livelihood, through influencing (negatively) the interviewee's assets.

The chapter then looked at the ways the respondents learnt, gained new knowledge such as 'learning over the electronic hedge', before considering the examples of AaSF and climate-resilient farming such as reducing the use of machinery and using more efficient technology. The remainder of these techniques are raised as key themes in the paragraph below. The chapter finally looked at the barriers and drivers which might affect (positively or negatively) a farmer accessing resources and new techniques.

[89] Time and distance are marked as part of the financial theme in yellow as it was related to the financial loss from taking time away from the farm or travelling long distances.

Throughout the chapter, even in the hazards and barriers sections, there were a variety of themes which suggested positive ways to encourage farmers to farm agroecologically and sustainably, improving their assets and become more climate-resilient to hazards.

Three major themes were firstly **improving soil quality** (particularly with arable farmers), and as a result sequestering more carbon. This relates to research question 2 as it could be a driver to changing behaviour. Secondly, **improving animal health and milk quality with grazing management and mob grazing** (whilst also increasing the root structure below ground), which relates to research question 1 as they were interventions which also improved a farmer's assets and thus their resilience. The third theme related to research question 2 with barriers to change and **addressed physical, mental and social health issues of farmers to remove sociological and psychological barriers**.

Chapter 7 will evaluate the results against the relevant literature, concepts, aim and research questions. This will then lead to the conclusion in Chapter 8.

Chapter 7 – Discussions, interpretations and limitations

7.1 Introduction

This chapter follows on from the two previous results chapters and draws together the key findings that have emerged from the analysis of the two phases of data. Chapter 5 examined the quantitative and qualitative results of the Phase 1 survey that was sent out in 2013-14 via the Internet, Twitter, web forums and email, whilst Chapter 6 explored the results of the Phase 2 detailed interviews of survey participants and those who had been on agroecological workshops (from 2015-16).

Using the UK Rural Livelihoods Framework that was developed in Chapter 3 (Figure 3-1) and shown reshown below (Figure 7-1), this chapter pulls both sets of results together alongside the theoretical framework from Chapter 2, aim and research questions, along with considering where and why parts of the analytical framework do not fit so neatly with the data.

Figure 7-1 UK Rural Livelihoods Framework adapted from the HULF for this research

The chapter begins by exploring the hazards and vulnerabilities that have emerged across the data, and during the data collection. These naturally include climate change and how it relates to the results, along with other vulnerabilities such as shocks, trends and seasonality.

The chapter then explores the farmer and farm needs before moving on to discuss in detail the assets and how the data relates to and confirms the usefulness of this part of the analytical framework. It considers the social, human, natural, physical and financial assets, where they overlap and link up, and where they build resilience to the hazards and vulnerabilities through adaptation and mitigation. This section also explores where farmers are transitioning towards agroecological farming, building their assets to further support their livelihood, whilst others are diversifying for the same reason.

The chapter moves on to explore barriers, those slowing if not stopping access to resources, but also (as discussed in Chapter 3) those which are hindering change in farming styles that might enable the farmer to adapt and mitigate against climate change and other shocks, and stresses. In this section, the chapter first reflects further (from Chapters 5 and 6), on the sociological and psychological barriers from changing behaviour to changing beliefs, the difficulties when lacking knowledge or practicalities, financial barriers, and finally going back to Table 2-3 in Chapter 2.4.2, explores other barriers that appear in the data collected.

The resources are then discussed, together with ways that they link back to the assets and barriers concerning government resources such as subsidies or government policies (which might hinder or encourage change), resources from other organisations and finally inputs to the farm. Following this, other inputs to and outputs from the farm are explored.

Finally, the chapter considers the limitations to the research, limitations of the analytical framework (which is discussed both in this chapter and in Chapter 3) and also the limitations of the methods and methodology used in the data collection.

7.2 Hazards and vulnerabilities

Chapters 5 and 6 investigated hazards related to climate, finances and other shocks and stresses, which are now discussed further in relation to Chapters 2 and 3. This section addresses research question 2 regarding barriers, research question 1 where the discussion moves to adaption techniques, and if applied to the UK food system, these hazards could also address research question 3.

7.2.1 Climate change and weather and how they relate to the results, creating shocks and hazards

As discussed in Chapter 2, climate change and extreme weather patterns have and will continue to impact on agriculture. Negatively with the longer impacts over time from climate change and those more everyday from local weather (as explained in in the definitions at the beginning of the thesis), and more positively through the agroecological adaptation and mitigation techniques which can work to reduce the impact, if not prevent serious climate change impacts on agriculture. Chapters 5 and 6 examined the hazards alongside references in the data relating to adaptation and mitigation techniques building resilience, whilst this chapter moves the adaptation and mitigation discussion to the assets Section 7.3.

Some of the survey participants felt that climate change could not be combatted, and all they could do was mitigate and minimise their impacts and increase their farm's resilience. However, the majority of respondents to the Phase 1 survey (from all four UK countries) and those interviewed (who only lived in England) commented on difficulties they had encountered on their farms with relation to weather[90], whilst still sharing techniques and agroecological methods that helped them cope.

In Chapter 2.2.3, the drought between 2010-12 and the extreme flooding over many of the recent winters was discussed, while Section 5.2.1 of Chapter 5 considered the responses in the survey in relation to drought, rainwater, flooding, the location of their farm and what they farmed. Chapter 6.3.1 briefly explored the unpredictable weather some interviewees were experiencing. Looking at the responses to reduced rainfall and drought creating hazards, most of the comments were survey responses and were discussed in Chapter 5. However, some of the interviewees did discuss the lack of rain, affecting the grazing of their livestock due to lack of grass growth and reduced water for growing their horticultural plants in the South-West of England. Comments relating to excess water and flooding included reference to the wet winter of 2012-13 significantly increasing topsoil losses, and pests such as slugs (Farmer response in survey, winter 2013-14). In the interviews, farmers were a little more descriptive in their explanations of the impact of excess rain, with one farmer from the East of England describing the geography of their farm, and how it was better suited to grazing animals than the arable that he was currently growing. He had found that in very wet winters, the steep slopes of his farm created run-off, erosion and deep and wide gullies (Farmer B, East, 2015).

In both the survey responses and interviews, where farmers talked about the weather, they also mentioned problems with unusual temperatures, particularly cold temperatures affecting their livestock and in some cases even killing some of them. Although others mentioned a lack of cold weather either benefited their products such as for flower crops to survive through the winter (Farmer ED, South-East, 2015), or hindered production with the lack of cold temperature not killing off the parasites and disease, creating health problems for their livestock (Farmer GB, Midlands, 2015).

[90] Reduced or excess rainwater, less predictable and greater extremes of weather, uncommon temperatures causing difficulties, and the impact on the health of the animals, water, land and farmers due to unusual weather patterns

One respondent in the survey reflecting the brief discussion in 2.2.1, felt that instead of a warming planet, the UK would face a freezing planet, quoting evidence from an astrologer and lay climatologist Theodor Landscheidt who has had articles published in peer-reviewed journals, seeming to offer evidence that the climate is not warming and humans are not responsible. After an extensive search of the Internet under the assumption that actual climatologists would debunk his writing (given that 97% of climate scientists articles agree that humans are causing climate change (Schmidt 2009)); only a few mentions were found of the lack of validity of his results (Trumpington Estate 2014, Macro and Farmers Weekly 2016). Instead, a plethora of websites and comments suggested that his work is valid, thus presumably leading to the mistaken belief of the survey participant and possibly linking to the comments from interviewees highlighted in 6.7.3 and 6.7.4 with regard to confusing research, impenetrable terminology and a perceived disconnect between farmers and researchers.

The last topic that related to climate hazards across the survey and interview results, was that of extreme and less predictable weather patterns: “we see the difference over the last 10 years, that you get extremes of everything” (Farmer B, East, 2015). Some farmers have had to prepare and plan for vastly differing weather than previously during their farming careers, storing the rainwater and taking advantage of sunny days to get on with farm jobs that require dry weather (Farmer ED, South-East, 2015). Examining how the unpredictable weather confuses the British seasons, previously farmers could plan their planting to make best use of the seasons. Those interviewed, and who completed the survey, indicated that more frequently now, it was no longer that simple, and required flexibility in when to plant, or when to harvest (Farmer AC, South-West, 2015). Some benefited from the warmer, sunnier winters, adapting (as discussed in 2.2.1 and 6.4.1) and leaving their livestock outside grazing until the end of the year (Farmer RH, Midlands, 2016). Whilst, as mentioned in Chapter 5.3.1, other farmers even had to go to the expense of hiring or buying grain dryers to dry their crops, as they are no longer able to always harvest during a long dry period.

Some farmers even adapted to harvest at night using large machines with floodlights and employing contractors to ensure that all their crops are brought in before a band of rain arrives, or the dew gets too heavy (Met Office Hadley Centre 2014: 4).

However, one interviewee summed up the uncertainty and unpredictability of the weather in the UK as to some extent had always been that way, explaining how they had visited a house where there were weather records for the last century. The records indicated that the weather was equally unpredictable across the last century with, in one year, snow in June and in another year, hot sunshine in December. They ended by stating: "So from our point of view we haven't had any thing that we would note that I would say is unusual. It is just the way, its just where we live, our latitude and longitude that is what we have." (Farmer EM, South-East, 2015). This reflected the Met Office, which in 2014, produced a report on their predictions of how the UK would fare with climate change, seeming to reflect the comments above:

> 'When viewed over long-term averages, the UK is expected to see more milder wetter winters and more hotter drier summers in the future. The role of human influence on our climate is already detectable on summertime heat waves and on the character of rainfall. But the UK has seasonal weather that also varies hugely from year to year due to natural processes. New analysis suggests that we should also plan to be resilient to wet summers and to cold winters through this century' (Lobley 2005).

7.2.2 Other shocks, stresses and hazards

Considering other shocks, stresses and hazards beside climate change, the first which appeared in the data was to do with finances. The data showed that this was tied in with the weather, creating financial loss[91]. Respondents referred generally to excess rain creating problems that negatively influenced their finances, from installing new drainage, to reduced bookings for their diversified activities (Farmers' responses in survey, winter 2013-14). Furthermore, the result of the unpredictability of the weather

[91] although the family of the researcher among other farmers had also suffered delayed subsides which were impacting their financial assets (Daneshkhu 2016a).

has created financial problems for some of the farmers in harvesting their crops during a dry period (Farmer response in survey, winter 2013-14).
However, other financial shocks which were not discussed in the data, were discussed in Chapter 3.4.2 and 3.5.1, with market volatility, and the price farmers would get for their crops or livestock fluctuating.

Other hazards included the health of animals, the household itself and their crops. Some of this was also due to the weather with one farmer describing how the wet weather had increased illness amongst their animals, which they have not experienced again (Farmer AC, South-West, 2015), and another finding pests and disease were not being killed during the cold temperatures of the winter (Farmer response in survey, winter 2013-14). However, other examples of health issues were discussed during Chapter 3.5.1 with farmers suffering depression (Syson-Nibbs et al. 2006), injury and pain (Thompson 2009) and even suicide (Naik 2016). Furthermore, one Nuffield Farming Scholarship (Ferguson and Lovell 2017) specifically looked at mental health in farming in the UK. These could all increase stresses on farmers, and may then reduce their resilience to further hazards.

7.3 Assets

This next section refers back to Chapter 3.4.2's descriptions of farm assets and examines in detail the five asset categories and how they are revealed from the data. It explores those that are intangible (social, parts of the natural asset (air) and parts of the human asset) and those that are tangible (physical, natural, financial and parts of the human asset such as health). These relate to research question 1 with respect to building climate-resilient farming communities, and research question 2 where assets can help drive change, for instance, when a neighbouring farmer shares successful techniques, or where restoring and improving an asset such as soil fertility would drive change.

7.3.1 Social assets

Exploring first the social assets, those of the farmer's relationships with family and friends, associations and social networks, revealed from the data, some stand on their own, whilst other social assets overlap with human assets. These are discussed further below.

Relationships and social activities

Examining first the social relationships and activities mentioned by participating farmers, there were many which could be related to improving their social assets, from advice and help to simply relaxing with friends. Farmers completing the survey mentioned how useful local knowledge, local farmers and family were to offer practical help on the farm when needed, or give advice or experience that could support the farmer.

Of those interviewed, many felt that visiting other farmers enabled them to learn new techniques, or see how that farmer solved similar problems. One farmer received help from farmers visiting their farm and helping them in situ (Farmer PV, South-East, 2015). Others benefited from farm social events, as discussed in 3.4.2's section on culture and 3.5.2's section on social assets. This included spending time socialising with their peers enabling the interviewee to share problems, seek advice and relax amongst friends, visiting the pub with their mates, or attending farming dinners and shows (Farmer MC, South-West, 2015).

As mentioned in Chapter 6.6.1, two interviewees (Farmer A, North-East, 2015 and Farmer RH, Midlands, 2016) felt they would appreciate a mentor to help them as they adapted their farms to new agroecological techniques. Farmer A wanted a farmer mentor who was just a little ahead with using the techniques, whilst Farmer RH wanted one who had already been through the process of adapting their farm. However, Farmer RH acknowledged that there was a lack of farmers in the UK who had already gained the required experience and therefore, similar to Farmer A's wish, everyone was learning together. A mentor would thus help build their social assets (along with their human assets of improving their knowledge).

Finally, one interviewee really appreciated moving out into the field after a lecture, to see how the topic could be applied in practice (Farmer HW, South-West, 2016), whilst another interviewee benefited from the structure of the RegenAG UK workshops which enabled him to share and seek advice over parts of mob grazing which he was finding difficult.

Organisations such as the PFLA, HM, RegenAG UK, and Soil Association

Many of the respondents for both the survey and interviewees were either organic, PFLA, or farmed using agroecological techniques. These organisations encourage communication amongst the members, along with farm walks to share knowledge and thus build community. Many interviewees had been on a RegenAG UK training course and were applying their learning of agroecological techniques to their individual farms, thus using what they learnt from the organisation to then improve the natural assets on their farms. There was even one who on paper looked conventional, but from their survey results and their interview, it revealed that they were transitioning to agroecological farming in order to improve their soil quality (Farmer response in survey, winter 2013-14; Farmer C, East, 2015). Those associated with organisations generally found that through support; communication; courses; and farm walks their agroecological farming was helped, and thus their social asset was strengthened.

Some of the respondents had even been on permaculture design courses, although of the three who mentioned permaculture, two felt that they could not see how it related to a farm, particularly with regards to grazing livestock management (Farmer A, North-East, 2015). However a recent article by Ferguson and Lovell investigating 60 permaculture farms in the United States of America, found 24 were farming large animals (mainly pigs and dairy) and 14 were farming smaller animals (mainly poultry) (Ingram and Maye 2017), which suggests that it is possible and maybe is just not common for the larger farm animals within the UK. Certainly, Ingram and Maye discussed gardens, public spaces, smallholdings, allotments and community farms which most likely have no animals larger than pigs and goats in the chapter of their book giving an analysis of agricultural knowledge in relation to the permaculture community in England (Haye Farm 2016, Clegg 2017, Havard and Agricology 2017). However, the overlap between permaculture, PFLA, organic, RegenAG UK and HM has grown closer over the last few years (for example, many similarities were shown in the review of permaculture and holistic management literature in Chapter 2), with farmers applying principles of two to five of the techniques on their farms (Hosking 2015, Permaculture magazine 2017). Furthermore, the Permaculture Magazine has reported on regenerative agriculture and pasture-fed farming over the last few years (The Farming Community Network 2013), so permaculture design training for larger animal farms may develop in the future.

One interviewee, a doctor, found that through farming organically and biodynamically and applying those practices, it related to the interviewee's ethos of whole health of the soil, livestock and health vitality back to the farm (Farmer ED, South-East, 2015).

The NHS, education sector, religious bodies such as the Church of England and other institutional bodies

Public sector institutional bodies that provide opportunities to improve health, learning and other human assets also help build social assets.

There was very little overt mention of UK institutional bodies, let alone how they could improve a farmer's social assets such as attending a doctor or college. However, there were comments in both the survey and in some of the interviews relating to statutory bodies such as AHDB or bodies that work for political change such as the NFU, these have been quoted in Chapter 6. Many of the comments were not positive in their views of how either could improve social assets. In contrast, one interviewee discussed his role in the church in his village with discussions of how he wove farming into his church’s calendar. He also belonged and supported the FCN (Burbi and Hartless Rose 2016), writing advent reflections for those who use the FCN resources (Farmer GB, Midlands, 2015).

Two survey participants mentioned that they had education centres on their farms, but did not expand to explain if schools used them, just that the education centres provided an income, thus improving the financial asset, rather than the social. However, one of the interviewees did encourage schools to bring their pupils to visit and adapted her farm visit to fit whatever topic the children were studying, and found that she learnt alongside the children (Farmer AC, South-West, 2015).

As mentioned above in connection with the NFU wanting to encourage young people to consider agriculture as an appropriate career, the group interview participants felt one weakness to embedding regenerative agriculture was the current agricultural education establishments due to the mainstream conventional focus. However, it could be an opportunity, as colleges begin to look at new approaches. One interviewee mentioned the difficulties of changing those who trained at agricultural college, where they were taught conventional farming techniques which differed from agroecological methods such as the ones the interviewee was using (Farmer PV, South-East, 2015).

In fact, in July 2016, Harpers Adams University organised, hosted and ran the 12th European International Farming Systems Association (IFSA) symposium in which data from this thesis was presented in a workshop (Blackmore 2016). In addition to the traditional and conventional farming courses that the university ran, during the conference it was apparent that some members of the college staff who attended were already using precision farming and robotics to reduce soil compaction, minimise tillage, and apply farming chemicals with greater precision to reduce run off (Hartless Rose 2016).

Furthermore, one survey participant responded as a lecturer of a farming college: on the college's farm, they were already practicing manure management, grazing management, minimum tillage, permanent soil cover, converting field edges for wildlife, collecting rainwater from the roof of their new dairy, generating renewable energy and reducing energy use (Farmer response in survey, winter 2013-14).

Another interviewee who was not only a farmer, but also a medical doctor explained how their farm was on the grounds of a hospital and that enabled them to share their agroecological farming techniques with patients and their families, and they are really responsive and interested in the farm's ethos and products (Farmer ED, South-East, 2015).

Culture, belief, worldviews…

Whilst there were no interview questions or survey questions designed to extract participants' thoughts on their local or national agricultural cultures, beliefs, identities and lifestyles impacting on their social assets (as discussed in Chapter 3), some results did indicate consideration of motivating factors beyond the farmer's personal beliefs. These varied from one survey participant pointing out that they got help from friends due to everyone experiencing the same problems (Farmer response in survey, winter 2013-14), to an interviewee pointing out the fact that social media has changed people's perceptions of finding data and remembering things as easily (Farmer GB, Midlands, 2015). Others discussed (linking with farmer learning in the human assets below) how they felt that once they understood the concepts of organic or permaculture growing, they did not need to attend workshops (Grower, Midlands, 2015), however another felt that once they had learnt a technique or concept through research, it really embedded it to attend a course on the topic (Farmer HS, South-West, 2015).

Another farmer suggested that the local farmers in their region might not consider the new agroecological farming techniques that were being developed on their land, as the interviewee was fairly new to the sector. However, they suggested that if a farmer from a generational family farm started to use the agroecological techniques, there might be more of an impact with other local farmers in the region (Farmer A, North-East, 2015). Finally, Advisor A interviewed mentioned that for some farmers, "It's a lifetime choice rather than a business on a lot of farms" (2016). Instead of profit and loss driving their behaviour, belief would drive their decisions, thus improving or reducing not only the social asset, but also the other assets depending on what the farmer would decide.

IT and learning connecting farmers together

Considering IT and learning, this could be placed as a human asset, as education and learning improve a farmer's knowledge. It could also be considered as part of accessing resources, as to use the Internet, a farmer needs to have access to broadband or dial-up. However, with respect to this thesis, it is to be considered as part of the social asset as knowledge is increased via Internet communication through web forums and social media (across an electronic hedge) which connect farmers together. This was discussed in detail in Chapter 6.4; however, it will be explored briefly here.

Throughout the interviews and meetings with farmers at conferences and workshops, it became noticeable that geographical distance separated those farmers who were using, and could be sharing experiences about, the same agroecological techniques. This problem was overcome using the Internet, creating virtual electronic hedges between farmers at opposite ends of the country, but farming using the same techniques which is discussed on Coventry University's research blog (TFF 2016). This was highlighted in the interview with Farmer RH who had had emails and communication with a variety of farmers from the UK and other countries sharing their experiences and appreciating the help, advice and experience shown in his Youtube videos (Farmer RH, Midlands, 2016).

Other farmers found using the Internet and specifically *The Farming Forum* (EU SCAR 2012, Burton et al. 2006) or the PFLA google group really useful in sharing experiences with other farmers as discussed in 6.5, as they generally only had replies from those who were interested and could offer advice, share pictures and make contacts (Farmer C, East, 2015).

In the light of the Brexit vote and the Trump election in the USA, there have been numerous discussions in the media over the meaning of truth and whether what one reads on social media is correct. Whilst this may not affect the data and analysis in this thesis, it could potentially introduce doubt regarding data on climate change and whether or not it is factual[92] (as shown in Section 7.2.1 and Chapter 2.2.1).

7.3.2 Human assets

As mentioned above and in Chapter 6, the last section of the social assets regarding IT and learning and the electronic hedge not only help to build social assets, but also human assets. Human assets include a farmer and their household community's knowledge, health, inherent skills, education and confidence. The farmers interviewed all seem to have appreciated learning in different ways - some prefer to observe a farming technique to aid their learning, whilst others preferred to move about and learn from doing an activity. As discussed in Chapter 6.4.4, electronic communication through social media and web forums, along with YouTube videos and email correspondence can help build an individual farmer's knowledge, and provide a support structure for a farmer if they are living far away from other agroecological practitioners.

[92] This would be despite the articles which review numerous climate and biophysical scientists published papers and agree that there is greater than 90% consensus that there is human-caused climate change (Maibach et al. 2014, Carlton et al. 2015, Cook et al. 2016)

Knowledge, education and skills

Many farmers now use the Internet to supplement their learning, researching new techniques and issues. As discussed in 2.5.2, website interventions such as Agricology have developed to help farmers learn and this was highlighted first in the survey with comments such as: ‘Own research’ and ‘Internet – opportunity to research a particular issue and gain a wider perspective then that typically offered by Defra/NFU’, and finally ‘You're not dealing with black and white solutions but progressively extending one's knowledge and understanding’ (Farmers’ responses in survey, winter 2013-14). It was also raised in the interviews, offering farmers the ability to learn without hiring an advisor, potentially saving money. One interviewee researched all the planning regulations behind installing a wind turbine, thus avoiding the costs of going through an agent (Farmer B, East, 2015). Whilst another interviewee had clearly spent a lot of time thinking and researching how to improve his farm to continue producing good yields of his crops, researching online journal articles to find the best ways to improve their soil health (Farmer C, East, 2015).

Traditionally, farmers used extension workers when seeking advice in order to improve their farms, techniques and understanding of problems they might encounter (Soil Association 2016). Despite the rise in individual learning and the use of the Internet to provide knowledge, both survey participants and interviewees still attended courses and used advisors as needed, which included drainage specialists, agronomists and catchment sensitive farming officers to offer advice and keep abreast of government initiatives (Farmers’ responses in survey, winter 2013-14 and Farmer C, East, 2015). Further linking farmers and researchers together, as mentioned in Chapter 2 with the Innovative Farming project (Hansen 2009), some organisations are even creating opportunities for farmers to set the topics requiring research, which could actually reduce the disparity between researchers and farmers mentioned by Advisor A (2016).

Changing a farmer's behaviour to encourage learning and thus strengthen their human assets.

Changing a farmer's behaviour could influence their human assets though encouraging a change in farming techniques to techniques that could improve knowledge, understanding, as well as improving the natural and physical assets such as the soil quality on their farmland; this is discussed further with regards to barriers in 7.5.1. One interviewee explained they had learnt through previous mistakes and experience that making jobs routine helped prevent future mistakes, and as a result they changed their behaviour to prevent further mistakes (Farmer ED, South-East, 2015).

Others, when asked about whether a farmer seeing the improved soil, pasture and healthier cattle over a hedge might make them reconsider their farming techniques, replied that they were beginning to see that and having farmers ask questions (Farmer EM, South-East, Farmer GB, Midlands, both 2015), which also points to potential drivers to farmers changing their behaviour as in research question 2. Whilst some traditional ways of farming (such as rotational grazing) can improve soil, other techniques may not improve the land or soil as much as agroecological and climate-resilient techniques discussed in 2.2.4 and 2.3.2, and farmers could find it hard to understand radically new techniques, let alone changing their practices away from the traditional methods without seeing the result physically (Farmer HW, South-West, 2016). Belief can also affect the understanding behind a technique. One interviewee explained it with regards to crop yield, and understanding that instead of adding yield by managing the crop well, you start with a good yield and "then every mismanagement thereafter you are probably knocking yield off rather than adding yield" (Farmer B, East, 2015). Farmer B went on to say: "It's a different mind-set, but that's the way we look at it so I always think it is always mismanagement rather than good management that wrecks the chances of a reasonable crop" (Farmer B, East, 2015)

Worry over family and the future can encourage a belief that it is necessary to change behaviours. Initially, this could reduce the human asset as stress and worry became prevalent, however once action took place, it's possible that instead the human asset can be boosted through the changing practices. Dr James Hanson, who testified in 1988 to United States Congress regarding climate change, wrote a book to encourage everyone to change their beliefs and behaviours with regards to climate change on behalf of our children and grandchildren (Smith 2012). Farmer AC had a similar epiphany when her grandchildren were born, which encouraged her to start farming using adaptation and mitigation techniques to become more climate-resilient. She also joined a climate action group which boosted her social assets. (Farmer AC, South-West, 2015).

Health and family household

As discussed in Chapter 3.5.1, the health of a farmer can create shocks and stresses which can impact on their ability to farm. Many of the health-related comments from the interviews that were mentioned in Chapter 6.3.2 were about poor health being a hazard for farmers. However, as part of the human asset, it is more about how the farmer's health can improve or reduce their human asset as their health changes. Some of the comments in the survey related to the farmer feeling too old to implement major changes to their farm, with the time required to reap savings taking longer than they would wish. However, one still considered energy reduction techniques that they could implement which they would benefit from: 'We feel at our age 60 plus that we would be better spending any capital on a shorter term solution to energy' (Farmer response in survey, winter 2013-14). Rather than seeing their age as a reason not to implement any agroecological changes, some of the interviewees considered how they could change their techniques, but factored in not overtiring themselves (Farmer A, North-East, 2015).

As discussed in 3.5.2, family members of a farmer can physically help and provide support and advice that can build the human assets. They can share skills and experience. Examples of this in the survey included: ‘Use experience of older generations’ or ‘Father knows best’ as well as ‘because the family is all involved’ (Farmers’ responses in survey, winter 2013-14). Furthermore, as discussed in 2.3.2, some of the agroecological techniques such as holistic management encourage family involvement (Farmer RH, Midlands, 2016) in every farm activity.

However, two of the interviewees initially found little support from their family and partners, since they did not understand the need for change and thus did not help to strengthen the human asset (Farmer PV, South-East, and Farmer AC, South-West, both 2015).

7.3.3 Natural assets

Whilst many elements of the natural assets here have been discussed in the previous two chapters, such as soil or livestock grazing, this section examines how they can build or reduce a farmer’s natural assets, and at the same time through adaptation and mitigation techniques, build climate-resilience. Depending on a farmer’s region, their natural assets could differ with different soil types, or more or less rainfall. Looking at the data from the research, it also included the topography of their farm, with one suffering landslips due to a steep farm with rain created gullies (Farmer B, East, 2015).

Managing and improving soil fertility and carbon sequestration.

As discussed in both Chapter 5.5.1 and Chapter 6.5.2, improved soil quality improves not only the farmer’s natural assets of a healthy soil, but also the yield of crops, and the health of animals which would improve a farmer’s financial assets. This appeared to be a strong motivator for some of the respondents in the survey and interviews, improving soil fertility to improve their crops. Furthermore, as discussed in Chapter 2.2.4, carbon is sequestered in the ground, and the process of using minimum tillage or cover crops or improved grazing land and crop land management (FAO 2015e) not only improves the nutrients into the soil, but also reduces the carbon released into the atmosphere.

Throughout the time of studying, gathering data and writing for this thesis, there have been some courses and workshops on soils as the topic gained relevance. Thus, 2015 was as the International Year of Soils by the UN (2016), and in 2016, both the Environmental Audit Committee (APPG on Agroecology 2016) and the APPG on Agroecology released reports from their 2015-16 soil inquiry (Environmental Audit Committee 2016: 36). Their recommendations included the point that more needs to be researched regarding the UK's soil health, urgent actions need to take place to 'improve soil organic matter' (APPG on Agroecology 2016); soils need to be included in any government climate change strategies; and government policy should encourage 'extensive farming over intensive farming' (Powlson et al. 2012, Lal et al. 2015).

Recent journal articles have suggested that minimum tillage may not sequester as carbon figures as high as originally stated (Merante et al. 2017), although others argue that as part of soil organic carbon management, it can still improve soil quality and its capacity to sequester carbon (2005). This disparity was reflected in the survey where one respondent mentioned carbon sequestration via minimum tillage and that the author Pete Smith had admitted it was not as effective as originally thought (Farmer response in survey, winter 2013-14). However, research regarding this suggest that the survey respondent did not fully understand the topic, as whilst Smith et al.'s article of 2005 that *Carbon Sequestration in European Croplands has been Overestimated* (Ingram et al. 2016), since that article, as mentioned above, many argue that it is still a valid technique for improving soil and mitigating against climate change. Ingram et al. discuss the difficulties in communication which occurred between research and farmer practice regarding soil carbon management and the importance of encouraging credible and relevant dialogue between research, advisors and farmers to improve understanding (Natural England 2016).

As mentioned in Chapter 6, conventional and agroecological farmers have been attending RegenAG UK workshops as well as soil carbon farm walks, both of which contained practical advice and farmer experiences which promoted the need for improving soil carbon along with improving soil health (Farmer HW, South-West, Farmer RH, Midlands, both 2016).

Most of the survey comments were in relation to improving the soil for improved crops and healthier soil, with cover crops, or green manures to increase soil organic matter, rather than to mitigate against climate change. However, carbon sequestration was discussed with Farmer AC concerning their permanent pasture, as much of the land had never been ploughed, so not only did she have good soil structure, but also it was a good carbon sink (Farmer AC, South-West, 2015). Another benefit of improving the soil structure is to increase water retention and mitigate against droughts. Thus, Farmer C had begun the process of moving towards minimum if not zero tillage by initially direct drilling as a trial to assess if his yield would reduce as the soil and water retention improved. He found that his crops had established well without a reduction in yield over the five years of direct drilling and has moved on to trialling no-till and cover crops to 'mitigate against increased frequency of extreme weather events and increased volatility in weather patterns' (Farmer response in survey, winter 2013-14 and Farmer C, East, 2015).

Adaptation and mitigation techniques for resilience to flooding and drought

Flooding and drought reduce the natural assets with regards to water. This is discussed in both Chapters 5 and 6. However, farmers have found adaptive or mitigating solutions that not only reduce the impact of those two hazards, but also improve the natural asset itself. One simple way was to collect rainwater to use when there was less water, which was discussed in Chapter 5.3.3. Other ways discussed in the last two chapters included Keyline ploughing which is used to great success in drier countries[93],

[93] One farmer who had experimented with the technique commented: "One of the things with the Keyline ploughing is again its climate specific I think. I think this is really a tool for capturing water in continental climates where they get most of the rainfall in short periods. They need as much infiltration and they want to get root deep organic matter deeper so they can hold more water. And obviously, you're ploughing on contours, subsoil on contours so you are infiltrating rather than running the water

but also has been trialled by some farmers in the UK (Farmer RH, Midlands, 2016). Another farmer used grants to plant trees to improve water absorption and reduce flooding and impacts of excess rain (Farmers' responses in survey, winter 2013-14). Further responding farmers built drainage, ditches and ponds to reduce flooding and retain water, or planted grass in the arable rotation to make the soil more water tolerant as well as increasing organic matter (Farmers' responses in survey, winter 2013-14).

Finally, one farmer was very keen to reduce his water pollution whilst improving his soil health, so he went on a course by Catchment Sensitive Farming (Hayhow et al. 2016) and then accessed the Government and Natural England grants and advice for improving his storage of crop sprays.

> "…We used them for the construction of a new sprayer store - we keep all our chemicals in there. The idea of that is that its contained, you're filling your sprayer up under cover. It's got a bio-bed fitted in it, so you're treating any surplus washings, drips, or things like that. The idea of needing to reduce pollution into water, that was quite clear" (Farmer C, East, 2015).

Biodiversity – reducing agriculture's impacts and gaining biodiversity benefits

This has already been discussed with regards to the Brexit decision in 7.2.2, but not only can agriculture impact on biodiversity, reducing the habitats and using pesticides which harm bees as mentioned above (FAONewsroom 2004, Convention on Biological Diversity 2008), agriculture can also benefit from biodiversity and thus improve the natural asset and biodiversity's important part of the UK's natural environment. Birds can spread seeds, insects can pollinate crops and microorganisms improve soil, but biodiversity also allows for genetic diversity, which could help in different agricultural and environmental conditions that are not suited to the conventional four plant

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off. In our climate, there is a potential risk with doing that because you can get earlier saturation" (Farmer RH, Midlands, 2016).

species (rice, maize, wheat and cassava) which are dominant in the plant based diet of humans around the world (FAO and Platform for Agrobiodiversity Research 2010).

Biodiversity could also allow adaptation to climate change in the UK through farmers planting new products (as discussed in Chapter 2.2.4) as the temperature increases, such as more vineyards, olive groves, and southern European fruit trees.

Examining the data, those in the survey who responded to creating field margins for wildlife to some extent could be seen as using land sparing, but if their pesticides used on the crops spread to the edges of the field and impacted on the wildlife, it would defeat the purpose of land sparing to improve biodiversity. In contrast, those who were farming organically were already using techniques which would not harm the wildlife and in the case of some of the interviewees, having their livestock on or alongside fields of common to rare wildflowers encourages both biodiversity and farming to work alongside each other (Farmer AC, South-West, Farmer GB, Midlands, both 2015, Farmer RH, Midlands, 2016).

One interviewee commented that she found her sheep ate the flowers whereas her cattle did not (Farmer AC, South-West, 2015), and in one RegenAG UK workshop another farmer, who was growing fields of rare plants for the local wildlife trust, was not allowing his cattle into that field at all to protect the plants.

Finally, an FAO report on biodiversity and agriculture suggests that the use of multiple species and breeds roaming as flerds can help livestock farmers ‘maintain high diversity in on-farm niches and to buffer against climatic and economic adversities’ and crop rotations, cover crops and ‘growing different varieties of a single crop’ can help crop yields (Chapman 2012, Thornhill 2014, Sewell 2014).

UK farming, through the natural asset, can be resilient to most climate change

As discussed above and in Chapter 2, the UK agriculture sector has options for adaptation as the climate changes. However, from conversations in the interviews, some farmers, through their natural assets, such as soil type, on their farms, are actually resilient to some changes in the climate. Whilst the survey revealed that some farmers felt their farms were suffering from climate change, others indicated that whilst flooding might cause problems on their farms, they did not suffer as severely in drier years. The interviews were a little more thought-provoking as they suggested that whilst flooding impacted heavily on their farmland, crops and livestock, drought was not such as serious issue for livestock farmers “because grass is far more drought tolerant than anything you plants like cereals...” (Farmer GB, Midlands, 2015).

Furthermore, one interviewee found that in one dry year, his crop yields were better than other years:

> “I suppose we don't talk about the drought quite so much, partly because we are fairly drought resistant farm because we are a predominately clay soil. However, I suppose this year we have had quite a dry year. I don't know where exactly we are to compare, with regards to rainfall, but I expect we are below average to this time of year and yet we have had one of our best years in yield terms, so I suppose a dry year tends to suit the farm” (Farmer B, East, 2015).

Grazing and animal health

This is first discussed in Chapter 2.3.2. and then examined from the data in Chapter 5.4.3, and is discussed in more detail with the Phase 2 results in Chapter 6.6.1. As a result, it is only briefly discussed here. Livestock and other farm animals fall under the natural asset (with regards to their health) and to some extent the physical asset (as a physical animal). However, for the sake of the assets in this chapter, livestock and animals will be discussed as natural assets for both their health and grazing.

Farmers interviewed, such as Farmer RH, who had adopted mob grazing found, much like the Nuffield Scholar reports mentioned in Chapter 2 (Ponder and Hindley 2009), that it improved their natural assets such as their grass and soil quality (Farmer RH, Midlands, 2016). This in turn enables the land to absorb more water, retaining the water in lower rain circumstances, and absorbing it in heavier rain circumstances, thus making the farmer's land more climate-resilient to both low and high levels of rain (relating back to research question 1). Some even found that their cattle and calves were in better condition (Farmer PV, South-East, 2015) although excess wet weather whilst rotational grazing did cause some problems for one interviewee (Farmer AC, South-West, 2015).

As mentioned above, livestock and other animals that can be sold can be considered part of the physical assets and selling them can improve a farmer's financial assets as well. However Ponder and Hindley comment that as many farmers take their livestock for granted, it can be seen as part of the entire livelihoods of that farmer, rather than an individual asset (Ofgem 2016a).

7.3.4 Physical assets

The physical assets look at the elements on a farm which are physically able to boost a farmer's livelihoods: so the buildings that they use, machinery and technology, and renewable energy.

Renewable energy

This topic crosses three assets – renewable energy devices would fall into the physical section of this chapter (7.3.4), renewable energy (sun, water, thermal energy, biomass) falls in the natural section (7.3.3) and the money saved or expense of installing would fall into the financial section (7.3.5). As a result, for this chapter, renewables are discussed in this physical section situated between the natural and financial.

In addition to the renewable energy generation reducing the financial expenditure on energy bills, they can also generate money for a set number of years through the government feed in tariffs (FIT) (Ofgem 2016a). However, as discussed in Chapter 2.2.4, the FIT has reduced over time. In 2010-11, a farmer installing PV could gain as much as 43.3 pence (p) per kilowatt hour (kWh) depending on layout and capacity. By June 2016, a new PV installation could only earn up to 4.53p per kWh (Ofgem 2016b). Those farmers, such as Farmer B, who completed the survey or were interviewed all appeared to have built their devices before the FIT got too low (Farmer B, East, 2015).

The renewable heating tariffs for biomass or solar hot water have not reduced quite as severely as the FIT, but are still reducing over time as target installations are met (DEFRA and Office for National Statistics 2017, Farmers Weekly Reporters 2017).

Some farmers, such as the one quoted above, have reduced their arable or livestock as the renewable devices take up space on their fields. Others farm around them, either allowing their sheep to graze in the field with PVs, or see the FIT as an income generation to cover any shortfall whilst they switch their farming techniques to ones which are more agroecological, such as minimum tillage (Farmer C, East, 2015).

Machinery and technology

These topics were discussed in Chapter 6.5.3 as well as (with regards to discussions on electronic learning from information technology) in Sections 7.31 and 7.32 above, and in Chapter 6.4. However, concerning a farmer's machinery and technology improving their physical assets, they enable the farmers to improve their farming in various ways. One is in reducing their workload (which could be with conventional farmers using a bigger tractor to cover more of their field at once, or for an agroecological farmer, finding placing the fences for mob grazing is a lot quicker with a quad than by walking and dragging the fences (Farmer PV, South-East, 2015). Another way could be by improving their soil or crops as precision machinery (discussed in Chapter 6.5.3) allows optimum nutrients to be applied at the most suitable time, whilst a direct drill would enable a farmer to reduce their tillage (Farmer GB, Midlands and Farmer C, East, both 2015).

However, the costs to purchase the machinery or technology could reduce the financial assets (as discussed in Chapter 6.5.2) along with the costs to maintain the machinery and technology. They could be sold to improve the farmer's financial assets, but they might not recoup the costs paid when purchasing the machine in the first place.

Furthermore, reducing machinery usage could reduce energy costs for fuel, and this would reduce emissions on the farm.

Buildings in use

As discussed briefly in Chapter 5, some farmers have additional barns and other buildings on their farm that enable them to diversify, creating income from 'light industrial buildings' and 'holiday cottage' for the farm (Farmers' responses in survey, winter 2013-14). Other buildings provide spaces for milking (Farmer MC, South-West, 2015), or for storing grain, or for filling up their sprays under cover to avoid polluting the waterways (Farmer C, East, 2015).

Buildings can also be a source of income, as is discussed below.

7.3.5 Financial assets

This section examines buildings and building capital, sale of goods and other income from jobs beyond the farm, and ends by considering subsidies. This asset is closely linked to the other four. For instance, if the farmer went back to college to learn how to be an electrician (human asset), they would then be able to earn additional income from that skill, whilst if a farmer expended some of their financial asset to attend a course, it could then help improve their soil or livestock (natural assets). As a result, there have been discussions relating to finances throughout Sections 7.3.1-7.3.4. The three sub-sections below specifically discuss hazards reducing the financial asset previously, either in Section 7.2.2 above, or in Chapter 6.3.1 concerning finances creating shocks and stresses. This section therefore instead, briefly explores how the three sub-sections can build (or reduce) the financial asset of the farmer and their household. It must be noted that those who are tenant farmers have impacts on their financial assets through paying rent which can often be high (Agricultural Industry GHGAP Steering Group 2011), whilst those who have mortgages on their land, may also suffer from higher monthly payments which could reduce their financial asset.

Building capital

As discussed above, buildings on a farm can be used for multiple purposes including leasing for additional income. However, if owned, they can also be re-mortgaged (along with the farmland) to gain further finances in severe circumstances and thus improve the financial asset (although the repayment of the mortgage could impact on negatively on the asset). Looking negatively, should those buildings need repairing, it may reduce the asset, although optimising insulation and ventilation of the buildings whilst they were being repaired would improve the efficient use of heating the buildings (Davies 2016, Black 2016).

Machinery or livestock could also be sold to gain further finances, although equally, upkeep of the animals and machines would reduce the asset.

Sale of goods and other income

As the farmers produce and then sell their goods, this boosts the financial asset. However, fluctuating market prices sometimes do not allow a farmer to break even. As discussed in Chapter 6.5.2 arable prices have been low, and the price of milk has also raised concerns amongst farmers (Farmer MC 2015, Farmer HW 2016, both South-West) (Barnes et al. 2010). This could require farmers to try to increase their yields, change their crops or diversify.

Many farmers in the survey had diversified alongside their traditional farming. Whilst some of the interviewees also had adapted to grow flowers, renew energy and have holiday rentals (Farmer ED, South-East, Farmer B, East, Farmer AC, South-West, all 2015), others acknowledged the changes in the price of arable crops could encourage further diversification (Farmer HW, South-West, Farmer RH, Midlands, both 2016). Exploring the pluriactivity of the interviewees (see Chapter 3.3), two were working outside their farms, one as a medical doctor (mentioned above) and the other worked in conservation (Farmer ED, South-East and Farmer A, North-East, both 2015).

Subsidies and grants creating income

Subsidies from the government and the EU are discussed in Section 7.2.2 and also relate to Section 7.6.1, because they have to be paid to the farmer (as a resource) before they become part of a farmer's financial assets.

Farmers in the survey all indicated if they were part of an environmental scheme and most were receiving subsidies from DEFRA or regional bodies (Chapter 5.1.5). Farmers interviewed benefited from changing to different subsidies, but also found changes in funding created gaps where farmers did not receive their subsidies (Farmer AC, South-West, 2015).

7.4 Needs of the farmer and their farm household

As discussed in Chapter 3.5.2, the needs of the farmer can depend on the farming style or farming sector. However, certain needs such as water, food, energy, communication, health and education can be provided through the assets as well as by accessing resources. This section relates to research question 2 with regards to drivers and barriers to change.

Following the review of literature, whilst needs were assumed to be required by those being interviewed and completing the survey and hence added to the analytical framework, none referred to any of the above list specifically as a need. However, in reviewing the assets, the different needs on the list were revealed more generally such as the importance of gaining knowledge (education) to use a technique. As discussed at the beginning of 7.3.2, farmers need a certain level of learning, skills and knowledge to farm. Considering the other needs on the above list, there were conversations in the interviews about health and how when a farmer's health was poor, it could hinder farm activities (as discussed in the latter part of 7.3.2). In the survey, there were questions regarding energy (reducing energy use, or using renewables, discussed above in 7.3.4) and water (excess flooding, water shortages, discussed above in 7.3.3). The importance of communication was raised with respect to learning, and also to create the digital electronic hedge between farmers living far apart geographically.

Some of the needs would arrive naturally as on-farm inputs such as rain, or photovoltaic energy, whilst others would require off-farm inputs from resources such as communication networks, or fuel for tractors. These resources are discussed more in 7.6 below.

7.5 Barriers to accessing resources and changing behaviour

This section considers the analytical framework Figure 3-1 and how it suggests that barriers reduce or prevent access to resources. However, much like those in Chapter 2, which could be seen as barriers to change, the barriers here also consider those that hinder change. This is because they can be linked together. As a result, this section relates specifically to research question 2. A farmer might feel they are not able to access a resource such as knowledge to adopt an agroecological technique due to the lack of finances to attend a course. Thus, the lack of finances provides the barrier to the resources of the course, whilst in consequence, the lack of the knowledge that would have been gained at the course would provide a barrier to the farmer changing their behaviour. The barriers identified in Chapter 2 are discussed across four sections, but are focused on particularly in Section 7.5.4 which compares the data to the barriers in Barnes et al.'s DEFRA report (Barnes et al. 2010, Fleming and Vanclay 2010, Silici 2014).

7.5.1 Sociological and psychological

As discussed in Chapter 6.7.4, in addition to the more common financial, educational, or structural / administrative barriers identified by academic and government research (Mezirow 1991), which are discussed below in 7.5.4, sociological and psychological barriers appeared during analysis of the data. These bear more relation to barriers to change (which would then impact on accessing resources, rather than barriers specifically stopping access to resources). They included belief and cultural barriers along with issues such as age and health (which were discussed in 7.3.2) and a farmer's willingness to change. Some of the survey participants indicated, in questions 15 and 16, why they were not implementing any of the listed techniques, and many felt that energy reduction techniques, maintaining permanent soil cover and converting field margins would not work on their farm (Farmer responses in survey, winter 2013-14). Some of the interviewees mentioned that pride, or belief made it difficult for them to ask for help, or implement new techniques (Farmer RH, Midlands, 2016 and Farmer C, East, 2015).

Belief is a strong barrier, if a farmer strongly believes that climate change does not exist, then no matter the scientific evidence, they are unlikely to change their farming style as discussed in 5.5.3 (Farmer response in survey, winter 2013-14). Equally, as discussed in 6.7.4, if a farmer believes they know the answers (even if they are incorrect), they may not listen to advice given (Farmer GB, Midlands, 2015).

However, in order for a farmer to change their farming styles, they need to acknowledge that a change is required which may need to be transformative (learning knowledge that not just adds to their meaning perspective framework[94], but changes it following a transformative challenge). For some farmers, such a challenge may instil resistance rather than transformative learning, thus creating barriers to change for

[94] This could be viewed as a metaphorical filing cabinet containing all the experiences, beliefs, attitudes, emotions and opinions that have been developed since childhood of the farmer (Mezirow 1991). There could be more than one filing cabinet, (for instance one for family, another for the farm).

them (potentially such as those in 5.5). Only when many such challenges arise simultaneously, or when the environment upon which the challenge is presented is of greater concern, will the meaning perspective evolve, or dissipate and be recreated (Bandura 1994, Ozmete and Hira 2011). This concept was raised in the data, when analysing the recordings of one of the farmers who was both surveyed and interviewed. He was classed for the research as conventional (in that he was not organic, permaculture, PFLA or RegenAG UK), yet he wanted to improve his soil, in order to improve his crop yield: thus, potentially his meaning perspective may have changed in order to consider using new farming techniques (Farmer response in survey, winter 2013-14 and Farmer C, East, 2015)[95].

Equally, as discussed in Chapter 2.4.3, changing a farmer's behaviour towards more sustainable agriculture may be harder if there is a lack of self-efficacy. However, if a farmer believes they are capable of achieving a task, they are more likely to attempt it (Farmer RH, Midlands, 2016), and upon successfully completing it, their self-efficacy is reinforced (Dwyer et al. 2007, Mills et al. 2013, 2016). If, as in the survey, a farmer did use the technique and it was not successful, it may not have reinforced his/her self-efficacy.

Another barrier could be age. This appeared in the survey, as some farmers indicated that at their age (which was not specifically indicated), they felt introducing agroecological techniques was not the best use of their capital (Farmer response in survey, winter 2013-14). This would relate to both their self-efficacy, but also their willingness and ability to adopt new ideas (Drost et al. 1996, Barnes et al. 2010). Their personal belief that they were to old to try new techniques made them unwilling to change, whilst the fact that due to age, they were unable to physically introduce a new technique might fall under an inability to act. As mentioned in 7.3.2, Farmer A felt that despite his age, he and his wife were able to adopt new techniques, but in their

[95] However, without further research specifically using Mezirow and others relating to transformative change and meaning perspective frameworks, it would not be totally clear if this concept did relate to this farmer's change.

planning to introduce that technique (mob grazing), they needed to plan within their physical ability (Farmer A, North-East, 2015).

7.5.2 Knowledge and practicalities (educational barriers)

Whilst in 7.3.2, where a farmer gains knowledge it can help them build their assets and introduce new techniques, where a farmer lacks knowledge or the opportunity to access training, it can create educational barriers that can inhibit new learning. Drost and Barnes indicate that lacking knowledge or skills can restrict farmers' ability to change practices and creates barriers (2016). This correlates with the survey respondents in Figure 5-12, where 21% of the qualitative comments regarding barriers to adapting a technique were related to knowledge and practicalities (difficulties to converting (machinery, learning etc), prior knowledge that it would not work, and confusing research). Burbi et al. found that the advice given was not useful for GHG mitigation practices (Fleming and Vanclay 2010, Burbi et al. 2016) and furthermore confusion in research published reduced the trust of farmers on those topics (Rodriguez et al. 2009) which echoes Farmer C's (East, 2015) comments regarding conflicting research in Chapter 6.7.3.

Other reports and articles found similarly that lack of support from advisors (Ingram and Mills 2014) and lack of suitable discussions to share knowledge (Barnes et al. 2010, Dwyer et al. 2007, Ingram and Mills 2014) reduced the ability of farmers to learn, ask questions and gain knowledge about new techniques (2013). Mills et al. suggest that education (or the lack of it) hinders the ability of the farmers to take up environmental measures (2006), however Burton et al., suggests that advice alone may not encourage changing farming practices, or ability to access resources as (linking with 7.5.1) the farmers need to believe they can achieve change and gain access to resources (2010). Fleming and Vanclay suggest that it is not just the lack of knowledge but also the ability to evaluate the knowledge provided to assess what is useful that is the issue (Rodriguez et al. 2009, Dwyer et al. 2007). These problems were bypassed by interviewees who used the PFLA google group to ask questions, and start discussions on a whole range of topics from sale of animals, to carbon sequestration on their farms (Farmer EM and Farmer PV, both South-East, 2015 and Farmer RH, Midlands, 2016).

Another point is, if farmers who are attending a course feel that the trainer does not have actual farm experience (Farmer HS, South-West, 2015), or cannot adopt their training for different soil types or farming styles, then they may not have the actual experience to back up their knowledge (@beefyfarmer 2016, 2015).

IT and learning

Farmers could be hampered from adopting change if existing research appeared contradictory (Farmer C, East, 2015). Climate change was one topic that could split farmers, and whilst those interviewed did not deny it was occurring, some farmers on Twitter have used erroneous research to argue their point that humans have not contributed to climate change and it is not a serious as UN scientists make out (Rathbone 2016, Ofcom 2016a).

Furthermore, as discussed in Chapter 2.4.3, superfast broadband and mobile Internet have not yet reached all parts of the UK (Ofcom 2016b), reducing the ability of farmers in some areas to take advantage of online knowledge, with only 66% of properties in Herefordshire able to get superfast broadband, despite a UK percentage of 89% (Ofcom 2016b), and was apparent at the time of writing up the thesis whilst on this researcher's family's farm in Herefordshire. This disparity continues in Wales, Scotland and Northern Ireland as well with the lowest in Wales at 31%, Scotland at 29% and Northern Ireland at 58% of properties (Oreszczyn et al. 2010).

Some farmers, certainly in Oreszczyn et al.'s study in 2010, may be uncomfortable accessing videos, social media or articles and news, which could enable them to change their techniques, or access new resources (Dehnen-Schmutz et al. 2016). However, with the rise in smartphones, this may slowly change (Ingram and Mills 2014, Barnes et al. 2010, Fleming and Vanclay 2010, Rodriguez et al. 2009, Dwyer et al.

2007), and certainly this was not a factor amongst the farmers interviewed and surveyed (Farmer responses in survey, winter 2013-14, Farmer B and C, both East and 2015).

7.5.3 Financial barriers

As discussed in Chapter 3.4.3, many resources cannot be accessed without finances, such as purchasing seeds, or paying to go on a training course. Thus finances could provide both a barrier to the resources, but also to learning and beginning to adopt agroecological and sustainable farming techniques (Fleming and Vanclay 2010, Drost et al. 1996). Sometimes it is not just finances, but the time taken away from the farm, which would provide a barrier to change, or accessing resources (Farmer B, East, 2015), (Barnes et al. 2010, Ingram and Mills 2014, Mills et al. 2016, Taylor and Van Grieken 2015).

Occasionally a farmer might barter with their neighbour, offering loans of machines, or help with the harvest to gain access to a resource when finances are tight. Furthermore, as discussed in this chapter and throughout the thesis, finances can also provide hazards (6.3.1 and throughout Chapter 3), or reduce the financial asset (7.3.5) and through the impact on the financial asset, finances could impact on a farmer's ability to change practices or access resources.

Despite this, literature on AES schemes show that finances are most likely to provide a barrier as the result of reducing assets, or merely due to the cost required to purchase resources or implement change (Altieri and Nicholls 2005). It is interesting that the farmer who had instigated the greatest investigation and subsequent transition to minimum tillage was the farmer with the largest income in the survey (Farmer response in survey, winter 2013-14), whilst another adopted renewable energy products to benefit from financial incentives, thus farming 'renewable energy cattle grazing' (Farmer response in survey, winter 2013-14).

Some farmers have found government subsidies and multinational companies have restricted the farmers' ability to change and access resources (Ingram and Mills 2014). However, whilst the report mainly uses examples from Latin America and the Caribbean, other reports have explored European countries and found that a lack of incentives or subsidies provided a barrier to farmers to implement soil management techniques (2010). Furthermore, as discussed earlier in the chapter, some farmers participating in the data collection found that subsidies encouraged or hindered change to sustainable agricultural techniques (Farmer AC, South-West, Farmer GB, Midlands, both 2015).

7.5.4 Other barriers according to DEFRA's report by Barnes et al. (Barnes et al. 2010)

The remaining three categories of barriers mentioned in Table 2-3 of Chapter 2 are structural, management and administration (Rodriguez et al. 2009). Whilst these are discussed as barriers to changing farming techniques towards agroecologically farmed land, they also could be applied to barriers to accessing resources. For example, tenure agreements on a farm (structural) could stop a farmer from getting renewable energy (Barnes et al. 2010).

Some farmers responding in the survey about not employing agroecological techniques selected the option that *the technique would not work on their farm*, or *they tried the technique and it was not successful*. These could be assumed to be categorised as relating to management or structural barriers, but to confirm would require deeper analysis of the reasoning behind the selection of those options. If a farmer had selected the former option, it might be due to renting their land (structural), whilst if they had selected the latter option it might not have worked with their day-to-day operations on the farm (management). Where a farmer found policies and subsides required too complex paperwork for them to change to a higher environmental subsidy, this could relate to the administration barriers caused by the time it would take to complete the forms (Farmer response in survey, winter 2013-14) (Tashakkori and Teddlie 1998).

7.6 Resources to help build assets and assure farmer needs

Much of this has already been discussed above (such as subsidies (below), or the organisations as social assets in 7.3.1 or needs such as fuel) and so is not discussed in great detail below. However, like section 7.4, resources can help drive or create barriers to change, and so relates to research question 2.

One resource not discussed previously however, is resources of agricultural networks such as the PFLA. This was discussed with regards to building social assets in 7.3.1, but not with regards to the PFLA google group providing knowledge resources. Two of the Phase 1 survey farmers and six of the Phase 2 interviewees discussed how useful the resource was. However, like many resources, to access the PFLA discussion forum, a fee is required (Farmer EM, South-East, 2015): thus if a farmer was not willing, or could not pay the fee, they would not be able to access that resource.

Unlike the needs in 7.4, this section was more visible in the data collection, as the participants discussed communication (therefore accessing knowledge, Section 7.3.2), whilst others discussed renewable energy (Section 7.3.4) and how it not only gave them income (improving the financial asset, Section 7.3.5), but also reduced their need to access energy resources.

7.6.1 Government, subsidies and advice and services from other organisations

As previously discussed in Sections 7.2.2 and 7.3.5, most farmers who participated in the data collection received income from the Government (English, Welsh, Scottish and Northern Ireland governments), whilst others received income from the government for renewable energy (Farmer B, East, 2015). However, some also received advice such as pollution and water (Farmer C, East, 2015) or reducing nitrate fertiliser use (Farmer GB, Midlands, 2015).

Farmers also benefited from advice from other organisations (such as the NFU, PFLA, Soil Association for instance), in addition to Governmental advice. These were discussed in 7.3.1 above with regards to how they offered advice and training through web forums, workshops, email advice and social media, along with other organisations such as the FCN which offer emotional support and advice that can benefit a farmer's health, household, business and farm.

7.7 Inputs and outputs

Farm inputs and outputs, both natural and chemical were mentioned in both the survey and the interviews, although none were specifically defined as an input to the farm or output from the farm. As a result, this section is quite brief. However, it does link to research question 1 with regards to inputs and outputs which can help build climate-resilient farming communities. Outputs such as manure (which was turned into fertiliser) were discussed by many of the interviewees who mob grazed. Natural inputs such as water shortages were part of the survey questions. Input of seeds, antibiotics, animal feed and services were also discussed both in the survey results and throughout the interviewees.

Figure 7-2 below shows a collection of the words used from the participants that reflect inputs and outputs on the farm. The greater the number of responses the larger the word, so the word soil had the largest number of comments across the survey and interview responses. This reflects Chapter 3, Sections 3.5.3 and 3.5.4, which feature many inputs and outputs that relate to soil.

Figure 7-2 Word cloud generated in NVIVO from data collected and analysed, showing word usage in interviews and survey responses related to inputs and outputs

7.8 Reflections on the research, methodology and analytical framework

7.8.1 Of the methods and methodology

Mixed Methodology and methods applied

The data collection was planned to be a mixed methods two-phase collection with a quantitative Phase 1 survey and qualitative Phase 2 interviews (see Chapter 4.4.4). Based on the understanding of mixed methodology, and from the statistical and quantitative research methods workshops this author attended, it became apparent that despite designing the questions to provide quantitative results, due to the small sample (43 farmers with a wide variety of answers) the survey results were mainly descriptive statistics, less than half of which had any statistical significance. In hindsight, the survey could have been designed to produce responses, which would have provided stronger quantitative statistics. However, the results that were produced have generated useful themes, which helped develop the Phase 2 interview questions. So, the lack of statistical quantitative data was not a disadvantage to this thesis.

Furthermore, as the survey and interview questions both focused on contributing to answering the research questions (Morgan 2007); whilst gathering ideas and creating hypotheses from the observation of the survey results, and then evaluating those ideas and hypotheses with the interview questions (Ponder and Hindley 2009), the pragmatic paradigm and mixed methods are applicable for this thesis. In summary, this thesis is a mixed methods, social science exploration.

Using online tools for data collection

Whilst using BOS enabled farmers from across the British Isles and Ireland to complete the survey, due to the online nature of the survey, it only reached those who had Internet connections, or had personal connections to the author and could therefore receive the survey in the post. Twitter allowed a wider spread of respondents, however as discussed in Chapter 4.6.3, issues with the questions in BOS provided complications and possibly deterrents to some farmers who originally would have completed the survey. As a result, despite using an online tool, the number of respondents was low and the geographical scope of respondents (particularly in Scotland) was narrow. Beginning Phase 2, with its switch to interviews, allowed any confusion to be cleared up during the one-to-one interviews as well as delving deeper into relevant topics as they occurred.

Selection of farmers surveyed or interviewed

The selection of farmers for both phases was inevitably self-selecting. The selection of farmers for Phase 2 was limited to those who indicated they were happy to be interviewed. As a result, the results were possibly slightly skewed as the respondents who were interviewed were all to some extent farming in an environmental manner even if not yet farming sustainably and agroecologically.

Results for farmers who chose to complete the survey were possibly not as skewed, as there was a good cross section of sectors, farming schemes and comments regarding the agroecological techniques. However, for both phases, other approaches, such as using phone directories, or accessing registered businesses for further respondents may have gained a greater number of respondents.

7.8.2 Of the analytical framework

Whilst the analytical framework (Figure 3-1) was valuable as an heuristic device tool to analyse the data and interpret it with respect to the aim and research questions, it has been critically assessed for usefulness in this chapter as there were elements of the analytical framework which were less significant in the data (mainly as questions were not asked with relation to those elements), and therefore may not be required in the analytical framework.

As shown in the sections on needs (7.4) and inputs / outputs (7.7) above, these elements were not overly mentioned in data collection, as they were not seen as so relevant to answering the aim and research questions, and therefore not specifically developed into survey or interview questions for Phase 1 or Phase 2. However, as discussed in Chapter 3, there may be validity in keeping them in the analytical framework, as needs did appear when the data was analysed with regards to assets (revealing needs for energy, water, communication, health and education), whilst inputs and outputs can build assets, or increase hazards (rain can be collected and stored for dry seasons, but it can also create flooding); thus, these two topics could be researched specifically further to assess if they are required in the analytical framework.

Cross cutting themes such as renewables, or IT and learning, which developed during the analysis of the data, span multiple assets and were also not reflected in the analytical framework with the assets, despite sitting one on top of another. This could be reflected in the framework, if the pentagon of assets (discussed in Chapter 3) was reinserted into the wall as shown in Figure 7.3 below. The image shows two pentagons, suggesting visually that all assets can be used to be resilient to the hazards, shocks and stresses (as shown in Figure 7.1) approaching from the right-hand side of the wall, depending on which were most suitable. However, Figure 7.3 has not been added to the complete revised framework Figure 7.4 below as this researcher feels it needs further research and development to fit it into the symbolic wall (which originally was designed from a disaster management point of view as a 'structural wall' barricading the household against the hazards).

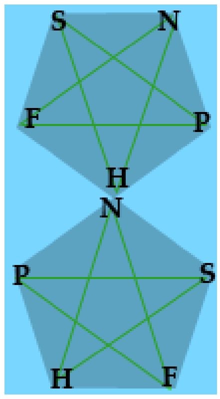

Figure 7-3 Cross cutting themes spanning more than one asset

Furthermore, topics such as adaptation and mitigation, or diversification branch across both assets, needs, resources and barriers and are also not reflected in the analytical framework. If the analytical framework was used further in UK agroecology and farmer sustainable livelihoods, these cross cutting themes would benefit from being researched further to assess fully if they could to be integrated in the analytical framework.

The analytical framework only suggested that the barriers were to restrict access to resources and change that would happen merely as a result of accessing resources, but as clearly shown throughout this thesis, this element of the analytical framework failed to consider the sociological and psychological barriers against change, changing behaviour, and / or changing farming techniques. This is shown in Figure 7.4 below.

As a result, whilst the analytical framework was a useful tool for the analysis of the data, without some revision it may not be quite so helpful for further research regarding sustainable livelihoods for UK farmers.

Figure 7-4 Showing the revised UK Rural Livelihoods Framework with sociological and psychological barriers to change

7.9 Summary

This chapter has explored how the data collected reflects on the analytical framework Figure 3-1 from Chapter 3, whilst discussing the themes from the theoretical framework (shown as a diagram in Figure 2.3) in Chapter 2. Examining first the hazards and vulnerabilities UK farmers face, the chapter explored the possible threats to Brexit that are discussed in the UK parliament and media, alongside climate hazards. The chapter then went on to examine the assets from the social (including the electronic hedge), human, natural (including soil and grazing), physical and financial assets, before continuing to explore the analytical framework in order to briefly assess farm and farmer needs. The chapter then explored how the data fitted the barriers section of the analytical framework, how it looked beyond barriers to accessing resources, and also considered barriers to change, including sociological and psychological barriers. This was related back to the theory in Chapter 2. Finally, the chapter explored the last elements of the analytical framework, those of resources, inputs and outputs, both of which were topics which appeared throughout this chapter.

The chapter finally ended with a reflection on the research, methodology and framework used throughout this thesis: where the tools were useful, where they fell short, where the data had limitations and where it could lead to new research.

The final chapter of this thesis follows, exploring the key findings, implications and significance of this research, contributions to theory, policy and practice and future research.

Chapter 8 – Conclusions

8.1 Introduction

Following the discussion in Chapter 7, this final chapter concludes the previous seven chapters along with comment on the important topics that arose from the research. Before concluding this chapter, the thesis is first recapitulated. Following this, the key findings that have emerged are explored. Succeeding that, a contemplative, yet analytical discussion of whether the aim and research questions have been achieved is followed by a reflection of the degree of significance of the study to the field of agroecology, sustainable rural livelihoods, and climate-resilient farming in the UK.

This chapter then considers the recommendations and suggested opportunities for future research that have developed from this thesis. These are relatively eclectic and range from social science, to physical science, to technological opportunities.

8.2 Recapitulating the thesis

The findings from this research aimed to advance current knowledge, theory and even practice concerning agroecological farming and resilient livelihoods in the UK to mitigate and adapt to climate change.

Chapter 1, the introduction, justified the need for the research in relation to problems of climate change, agriculture and sustainable livelihoods. The aim and research questions for this research were laid out, before a summary of each chapter was introduced. These were revisited in Chapter 4, along with a brief exploration of the methodological paradigm that shaped the study before the chapter introduced and considered the research design. Both of these chapters referred to the aim and all the research questions.

Chapters 2 and 3 proposed and discussed the theoretical and analytical frameworks respectively. Chapter 2 examined and reviewed the central literature, generating a framework of the current concepts that underpin the phenomena that occur with agroecology, resilience to climate change and resilient livelihoods of farmers, and aimed to meet research questions 1 and 2. Chapter 3 then conceptually explored the variables that formed that phenomena and how they can be better understood, meeting research question 1. From this, the chapter presented the framework Figure 3-1 to guide the data collection.

Chapters 5 and 6 imparted the resulting data collected and the empirical analysis of the Phase 1 (Chapter 5) and Phase 2 (Chapter 6) data, meeting all three research questions.

Using the analytical framework of Figure 3-1 from Chapter 3, Chapter 7 then discussed the two phases, together with their difficulties and similarities, whilst connecting back to the theory from Chapter 2, meeting all three research questions. The limitations to this thesis were also discussed in Chapter 7, whilst the key findings which have emerged, along with their implications are discussed in depth in this chapter below.

8.3 Unique key findings and implications

There are five key findings emerging from the research, which can hold implications for promoting agroecology and sustainable farming livelihoods through climate-resilient farming across the UK. These are discussed in detail below, but to list, they are:

1. Sustainable livelihoods in the UK,
2. Soil management as a mitigating method,
3. Sociological and psychological learning and barriers to learning / change,
4. Peer knowledge exchange, support and communication via the digital hedge,
5. Farmers learning new techniques outside of organisations

8.3.1 Sustainable livelihoods in the UK

Despite this being an element of the aim and research questions, the first key finding was that of the importance of sustainable rural livelihoods in the UK and their relevance to agroecology and the farming sector, as this is not overly discussed in academic literature. An exploration in the early chapters of the theory and concepts of sustainable livelihoods in the UK, formed the structure for the data collection and discussion.

Over the last fifteen years, farms in the UK have experienced a number of shocks and hazards from foot and mouth and TB scares, to excess snow or flooding, whilst experiencing stresses such as the price of animal feed and production not proving cost-effective to the farmers, thus not sustaining their chosen way of life. When studying farmers in the UK, applying a livelihoods approach and assessing a farmer's assets (as analysed in chapters 5-7), their ability to access resources and how resilient they are to hazards, could therefore be a useful new approach to analyse a farm's resilience to climate change, since it provides a lens though which to assess a farmer and consider if their household and its assets can withstand hazards.

This research suggests that a livelihoods approach could not only be used to assess the farming community, and potentially as with Oxfam's report, through sensitive use of sustainable livelihood tools, it could help farmers discern the areas needing intervention to improve that part of the farmer's livelihood (Dwyer et al. 2007). This approach might benefit networks such as the FCN that work to support UK farmers.

8.3.2 Soil Management as a mitigating method

The second key finding that initially bore fruit in Chapter 2, was the importance of soil management as a mitigating method for climate change. However, over the course of Chapter 3 and then data collection, not only have those mitigating potentials been confirmed, but also it has been shown that by creating a healthy soil, a farmer can improve their natural assets. In addition, the farmers indicated that they believed that a healthy soil can improve a farmer's crop yield, animal health, water retention, and reduce machinery use, potentially therefore also improving the financial and physical assets as well as the natural ones.

In fact, soil quality played a big part in the majority of the Phase 2 interviews, with both the conventional farmers and those more agroecological farmers (such as people interviewed who had attended a RegenAG UK course, or were organic or part of the PFLA who were working to improve their soil). Moreover, as discussed in Chapter 7, as soil is so vital to food production, mitigating against not only climate change through carbon sequestration, but also against flooding and drought, potentially it could be a way to encourage more farmers to consider agroecology whilst improving their soil that has been degraded over many years due to intensive farming.

8.3.3 Sociological and psychological learning and barriers to learning / change

Following an exploration of behaviour change and barriers to change introduced in Chapter 2[96], the third finding was uncovered to greater understanding following the data collection, when it became apparent that no matter how many incentives or regulations were introduced, some farmers still would not change their farming style.

Factors such as a farmer's beliefs, their health and age, their self-efficacy, their meaning perspective framework and their norms (which are all discussed in Chapter 7) can play a major part in whether or not a farmer is 'willing to change' (Ofcom 2016a).

Whilst these barriers may not relate back to Figure 3-1 in terms of barriers to accessing resources, they (through hindering change) could thwart a farmer's attempts to build resilience to hazards such as climate change. If through changing agricultural practices, a farmer could strengthen their (and their farm's) resilience to shocks and stresses by building up their assets, then any barrier to changing those farming techniques would make the farmer less resilient and more likely to experience significant hazards such as flooding or drought.

[96] Other behaviour change models of less relevance to the thesis are discussed in Appendix 1

In addition to the more obvious tangible barriers such as a lack of finance or education, or structural barriers such as land ownership, social and psychological barriers can hinder accessing resources as well as changing farming techniques.

8.3.4 Peer knowledge exchange, support and communication via the digital electronic hedge

The fourth key finding emerged from the data rather than the theoretical and conceptual chapters and could be regarded as new knowledge. It revealed that beyond local geographic networks of farmer learning, electronic farmer-to-farmer knowledge sharing through digital communications, with peer-to-peer discussions, debates, photos and videos enable farmers to look over the digital e-hedge. Whilst it must be acknowledged that rural superfast broadband and mobile Internet are still being rolled out to many parts of Scotland, Northern Ireland, Wales and parts of England (PFLA 2015b), where it already exists, it has enabled farmers (who are learning new agroecological techniques, or new technology) to communicate with other farmers situated counties away. Farmers can look up knowledge, gain advice or share frustrations whilst sitting in their tractors in their fields rather than waiting until they get back to their farm office or the local pub. This has also enabled farmers who feel isolated in remote areas of the UK to be part of an agroecological community across the breadth of the country.

When looking through the livelihoods lens, the digital e-hedge can build a farmer's human and social assets through knowledge exchange and emotional support from farmers of a similar mind-set no matter their location. This can provide encouragement when the local farmers remain unsupportive of agroecological and sustainable farming techniques.

The PFLA Google group are a good example of this, as discussed in Chapters 6 and 7, with discussions ranging from accessing water when mob grazing, to selling and buying cattle (DEFRA et al. 2017).

8.3.5 Farmers learning techniques outside of organisations

Whilst this finding is of interest, it was not quite so noteworthy as the previous four. Tying in with the previous section on e-hedges, technology has enabled farmers who learn using different learning styles such as kinaesthetic, visual or audio to gain new knowledge when more traditional routes to learning may not have been compatible with their learning style. Videos, podcasts, and web-streaming of conferences can all help visual learning, much like farm walks and looking over a physical hedge, rather than learning by listening to advisors or reading articles.

Furthermore, where farmers may not have had money, or the time to drive to, and attend workshops and conferences, web streaming and Twitter feeds allow them to take part without cutting too much time from their working day.

When planning a farming conference, workshop or education programme, consideration of encompassing the different methods of learning, along with online access to the event, would enable farmers to access the knowledge no matter their they preferred way of learning, and regardless of whether or not they can afford to pay for the training or take the time off to travel to an event.

8.4 Was the aim and research questions achieved?

The aim and research questions were introduced in Chapter 1, whilst they were revisited along with the introduction of objectives in Chapter 4. These guided the research from the theoretical and analytical frameworks to the research design and the data collection, before, finally, the evaluation of the data. The extent to which each was met is discussed below, and then summarised in Table 8-1.

8.4.1 Was the aim completed?

To explore agroecological practices and behaviour change on UK farms in relation to building climate-resilient farming communities and livelihoods.

This research aim provided the direction of the research, and the launch point for the structure of the whole thesis from the initial literature review, to the research design, data collection and final discussions. Whilst an extended exploration of different behaviour change models was only discussed in Appendix 1, a brief exploration along with a more detailed one on drivers and barriers to change was introduced in Chapter 2, with further discussion in Chapter 3. The results and discussion from the analysis of the data indicated that the aim was completed, with explorations of agroecological practices discussed both theoretically in Chapter 2 (organic, permaculture, holistic management and RegenAG UK farming communities) and more specifically in practice in the latter chapters. These chapters (5-7) examined further climate-resilient farming communities, their livelihoods and agroecological practices such as those farming with the PFLA.

8.4.2 Did the research answer the research questions?

The research questions add to the aim, unpacking it by providing the direction for the research.

1. What are the characteristics of agroecological interventions for building climate-resilient farming communities and ensuring sustainable livelihoods for UK farmers?

This was initially answered in Chapter 2 for agroecological interventions and climate-resilient farming communities, and with Chapter 3 concerning sustainable livelihoods. However, this research question was then answered more fully during the data collection, where first with the survey, and then following up with interviews, various interventions were discussed from workshops and organisations (such as RegenAG UK, or PFLA). Characteristics appear to include improving soil health through, for example, minimum tillage; cover crops; green manures; or permanent pasture and mob grazing.

Other characteristics include peer-to-peer knowledge exchange, awareness of the climate and environment and working to reduce the use of techniques that would negatively impact on them (such as nitrogen fertilisers), and considering the 'whole' of the farm from the household to the farming techniques. Many of these techniques then improve a farmer's resilience to hazards and therefore improve their livelihoods. Furthermore, the analytical framework of sustainable livelihoods provided the structure for analysing the data to critically recognise agroecological interventions (such as those listed above) that built climate-resilient farming communities and strengthened their livelihoods.

Whilst parts of this thesis and the research itself may appear to have focused too deeply on agroecological techniques, or parts of the livelihoods framework itself, this research question could be regarded as completed, as those techniques and the framework were examined with the intention improving climate-resilient farming communities, and thus ensuring sustainable livelihoods.

2. What are the drivers and barriers to behaviour change in farmers towards using more agroecological practices to build climate-resilient farming communities?

This question was critically answered theoretically in Chapter 2 and conceptually in Chapter 3, and then more specifically during both data collection phases. Whilst the survey provided choices for the responding farmers to select regarding why they might not change their farming practices, with the interviews, it was possible to go into more detail regarding reasoning behind whether or not a farmer changed their practices. As a result, this research question was answered fully in both the data collection chapters and the discussion chapter.

The hazards, plus needs, resources and improving the farmer's assets can all provide drivers to mitigate against climate change. These include needing to improve a farmer's knowledge; improving the soil to improve water retention as well as increasing the nutrients in the soil for healthy crops; and use of the Internet to improve the isolation of agroecological farmers in remote areas. The barriers to changing to agroecological farming practices included having the finances, knowledge and the skills to change techniques, along with the belief that the agroecological practice will benefit their farm.

3. What are the implications of such changes for the UK food system?

From the key finding in 8.3.2, the topic of soil health could play a major part in improving or influencing the UK food system. At present, UK soils are not in the greatest health and are low on nutrients needed for crops (Godfray et al. 2010, Seufert et al. 2012, Evans 2012). If all farmers in the UK were to make changes to their farming practices with one agroecological technique such as minimum tillage (to improve the UK's soil health), it might initially cause food prices to rise as farmers experience reduced yields as they adjust their crops to build up their soil (Reganold and Wachter 2016, Ponisio et al. 2014, Evans 2012, Godfray et al. 2010). However, subsequently, crop yields should improve with better soil health; thus, it should in theory eventually reduce the price of food (DEFRA et al. 2017). Equally, if all livestock farmers started pasture-feeding their animals, then that in theory would improve their income (due to a reduction in the cost of cattle or sheep feed (Gill et al. 2010), and potentially (based on the interviews, so further research would be necessary to confirm) an improvement in animal health). Furthermore, pasture-fed would mean reducing the amount of human edible food being used to feed livestock, and thus in theory may reduce the cost of arable crops and products made from them (such as bread) (Lampkin et al. 2015). Thus, agroecological interventions could benefit all farmers, and in turn improve food supply to the UK food system..

8.5 Did the significance of thesis stated in Chapter 1 prove realistic?

The significance of the study stated in Chapter 1 indicated that through considering agroecological change in the UK farming sector and how it is being applied, it would contribute to current knowledge regarding climate-resilient farming and farmer behaviour change. This was achieved through the results of the latter three chapters (5-7) of this thesis, exploring beyond the theory to the practical data. The results indicated how within the UK farming sector agroecological and climate-resilient farming can provide ways to improve soil quality, improve farmer livelihoods and allow their farms to be resilient to hazards such as climate change. This knowledge will be shared via the recommendations below, along with papers to be submitted for publication in due course.

This thesis also contributed to an understanding of agroecological knowledge sharing and exchange to influence and support farmers in the UK to change to sustainable farming practices. Through this understanding, organisations that are working with UK farmers, such as RegenAG UK, could apply new techniques to communicate, encourage and share peer-to-peer learning amongst the farmers that they are working with. This was then explored in detail with the interviews, where based on key finding 8.3.3 the Internet, social media and online communication are enabling farmers to share knowledge with other interested farmers. Furthermore, regarding the topic of soil health, this appears to be influencing more conventional farmers to begin to transition to agroecological techniques, changing to using less tillage and more cover crops. This knowledge will be shared in a report to RegenAG UK, along with contact with other relevant organisations, through articles written and submitted for publication in journals, along with conference papers presented.

Chapter 1's statements of significance finally suggested that the thesis might inform thought processes over the next decade with regards to farming policy, and the recommendations below aim to encourage that, along with further research and the publication of that research in journal articles.

8.6 Recommendations for policy and practice.

Whilst these recommendations overlap with the areas for future research in 8.7, these recommendations are more specifically areas drawn from the key findings that appear to be relevant to thought processes, agroecological organisations, universities and even government policy.

8.6.1 Academic research should link up with organisations exploring agroecological methods (similar to Soil Association's farm labs) in the UK

With the rise in interest in agroecology in the UK, based on the APPG on Agroecology, university centres and Lampkin et al.'s report into agroecological intensification (Laughton 2017), along with this research, further academic research into agroecology in the UK and the shape it has taken (in comparison to agroecology in Latin America for instance) would be useful. This has already occurred in an unofficial capacity with organisations such as the Land Workers Alliance being supported by the Centre for Agroecology, Water and Resilience, Coventry University (CAWR) (ORFC 2017), and with staff from CAWR presenting at the Oxford Real Farming Conference (The James Hutton Institute 2017). However, much more could be done, such as exploring the use of agroecological farming techniques on UK farms in detail, or with all the universities and colleges with an interest in agroecology (such as the James Hutton Institute (MacMillan and Benton 2014) and CAWR) working in partnership with agricultural bodies such as DEFRA, AHDB or the NFU. Alternatively, given the fact that the Soil Association farm labs have proved successful, utilising a non academic organisation to link farmer–researcher interactions could prove fruitful (Lampkin et al. 2015: 115). However, it must be noted that Lampkin et al.'s report states: 'While there is agroecological research taking place at some universities and research institutes in the UK, it is very dispersed and often not well connected to practical on-farm operations' (Mottershead and Maréchal 2017). Furthermore, in a recent report for the Land Use Policy Group (Mottershead and Maréchal 2017), during the reflections on agroecological approaches in other European counties, the authors felt that agroecological advice and education in the UK was of a fractured nature (as agroecological knowledge was held across private and voluntary bodies, universities and colleges and devolved and national governments). They therefore felt it might be more difficult in the UK than in France to ensure that farmers in the UK were able to access consistent advice regarding agroecological practices (without confusing farmers with contradictory guidance) (2015).

8.6.2 Farmer learning via the digital electronic hedge could be encouraged

Where farmers have found peer-to-peer learning online beneficial, it would be good to encourage them to share their experiences with farmers in their locality. In addition, as superfast broadband and mobile Internet get further rolled out in rural areas, farmers could do farm walks electronically using online videos, or a mobile video call carried around for the farmer watching to take part in the walk via the Internet. This may simply require a continued focus on broadband and mobile Internet roll out, but could also be promoted through website interactions like the two mentioned in 2.5.2 Agricology (2017) and Food and Farming Futures (RegenAG UK 2017, PFLA 2017, AgriChatUK 2014a), or through social media (Mckenzie et al. 2017, NIAB and AHDB Cereals & Oilseeds 2017, AHDB 2017).

In addition, as discussed with Advisor A, farmers who have gained advice, could then be encouraged to share it with their peers, both face-to-face and online. There could even be advisors offering online workshops and ‘surgeries’ for those who are too busy to travel to a physical workshop, but still would like to learn new techniques and gain new advice and insight.

8.6.3 Soil needs to become a priority for the government due to its use as a method to encourage climate-resilient farming, agroecological change and improve yields.

Whilst more is being done regarding soil since the UN year of the soils in 2015, with Brexit, the UK government has the option to change farming regulations and incentives to improve soil quality, health and encourage other agroecological techniques that improve the soil. As many organisations including the APPG on Agroecology have begun to recommend (see Chapter 7.2.2), as agricultural regulations and subsidies change following Brexit, soil health and climate-resilient techniques as listed in 2.2.4

and 2.3.2 become a priority to the government. Certainly agricultural industry bodies such as ADHB (Priestley 2017, FW Reporter 2017, Allison 2017) have begun to prioritise research into improving soils, and Farmer's Weekly magazine ran a series of articles on soil in September 2017 (2009).

8.6.4 Livelihoods approach could be used to evaluate farming in the UK

As shown in both this thesis and in Ponder and Hindley's report to Oxfam (Griffiths and Evans 2015, Kirwan and Maye 2013), using either the SLA or livelihoods Figure 3-6 (adapted for this thesis) to assess farming in the UK could be beneficial. In addition, as discussed above in 8.3.1, farmers could use the concepts such as their assets building resilience to hazards to evaluate how resilient their farms are to shocks, stresses and agroecological change (DEFRA and National Statistics 2015, Relf 2014). This might work with organisations such as RegenAG UK, tying in with holistic management and their analysis of the farm. An assessment could then be undertaken to determine if farmers would benefit from using the tools.

8.7 Areas for future research

8.7.1 Gender and agroecological farming

This topic was not relevant for study as part of this thesis based on the aim and research questions, however, following on from the assessment in 4.4.1, 18% of the Phase 1 farmers, and a third of the farmers interviewed in Phase 2 were female, and they had different reflections on, and reasoning behind why they had chosen to change their farming techniques to mitigate and adapt to climate change by introducing agroecological methods.

Whilst in other parts of the world the farmers are predominantly female, in the UK, this is not traditionally the case, although that is changing with more women beginning to work on farms (Jost et al. 2016, FAO 2010b). As a result, this topic has been researched both globally, for example with research in Uganda, Ghana and Bangladesh (Sumner and Llewelyn 2011), in more industrial countries (Riley 2009), including the

UK (Curry et al. 2012, Sutherland et al. 2013, Brunori et al. 2013, Labarthe and Laurent 2013, Del Corso et al. 2015, Mills et al. 2016). Consequently, assessing the viewpoint of female farmers in the UK and their understanding and views on climate-resilient and agroecological farming would be of interest beyond this thesis's remit.

8.7.2 The role of advisors in agroecological farming

Whilst farm advisors and extension workers have been researched extensively over the years, for example (Steenbergen 2015, Regenerative Agriculture UK - Courses 2017), there appears to be less research on agroecological extension in the UK and the role advisors can play in encouraging farmers to use AaSF techniques. An advisor interviewed for this thesis, indicated that despite the rise in farmer learning through the Internet and informal workshops, there was still a place for extension workers to offer advice to farmers from every sector of farming (including those farming more agroecologically). Over the course of writing this thesis, there have been workshops sharing agroecological techniques about improving soil (Farm Carbon Cutting Toolkit 2016) and farm walks with Warwickshire Rural Hub to share knowledge about soil organic matter (Dehnen-Schmutz et al. 2016). Thus, it suggests that this might be an area requiring further investigation, that of just who and how many extension workers are already sharing agroecological advice, and why others are not sharing that knowledge. Furthermore, as mentioned above in 8.6.2, advisors could offer advice via video calling, or social media, to group similarly interested farmers who live apart.

8.7.3 Social media and farm learning

Whilst farmer learning beyond traditional routes of advisors has historically been through peer-to-peer networks, research is beginning to investigate alternative methods of farmer enquiry such as research through smartphones (Deininger et al. 2011). However, little has been investigated regarding agricultural extension via social media. As discussed in this thesis, digital electronic hedges via social media on computers, tablets and smartphones have enabled farmers to share knowledge, ask questions and gain advice free from other farmers more experienced in a technique.

This was an unexpected (although in hindsight, not that surprising given the research started in 2011) result from the data and further exploration into farmer learning via individual different media may reap interesting results. From the data gathered for this thesis, Twitter was not limited to the younger farmers, nor Facebook, instead they seemed to be cross-generational in usage well as in topic, from marketing (Farmer GB, Midlands, 2015) to digital farm walks (Farmer RH, Midlands, 2016). From discussions on forums, to reading journal articles electronically, some farmers are becoming self-sufficient in their education, and researching this further could reveal interesting comparisons to the advisors' research above.

8.8 Final reflections

This thesis has been an intellectual and emotional journey over the last six years, stretching the researcher up steep hills at times, whilst stopping occasionally to ponder over the views, those theories and concepts both new (to the researcher), and previously studied. This in turn has allowed topics that were initially of personal interest, to develop rigorously into areas of academic research for this thesis.

The topics explored started off with a very wide remit due to an interdisciplinary background and it took a while to narrow them down, but having written up the entire thesis, the study has shown both opportunities for organisations and for research to improve and promote agroecological farming in the UK. By looking beyond the more traditional routes of organic farming only, avenues have been opened up that may not alienate those conventional farmers who do not want to convert their entire farm to an alternative system due to costs to change, and fears over lost income, yet still wish to improve their soil or animal health. Furthermore, through exploring the exciting data that has emerged in this thesis, from understanding the usefulness of the digital e-hedge to farmer learning and the value of applying sustainable livelihoods in UK farming, to considering the underlying intangible barriers that can impede change, innovative further research agendas can be developed.

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Appendices

Appendix 1– Further topics from literature review which became less relevant as the thesis progressed, but still of use.

A1.1 Behaviour change models

When exploring and promoting sustainable agricultural behavioural change for farmers or any individuals, there must first be an understanding of the different behavioural change theories and models which exist to promote change. Darnton, who in a comprehensive report for the UK Government examines over 40 theories and models, has different categories for the theories (Darnton 2008a). Those which seem most relevant and appropriate to behavioural change to sustainable agriculture are discussed below. Ozmete and Hira use different categories which will be used for this review below, in which some are based on psychological theories, others on sociological theories and others in economic theories (Ozmete and Hira 2011). There are other theories and models which are integrated and either use more than one model, or both theories and models.

A1.1.1 Psychological Behaviour theories

Darnton, suggests that most generally can only be used in the field of study that they were designed and only a few can be transferred across to other subjects (Darnton 2008b) However, Ozmete and Hira suggest differently as they look at a range of behavioural theories and models and assess their relevance with regards to financial behaviour change (2011).

Bandura's Social Cognitive / Learning Theory (SCT) or Theory of Self-Efficacy

This has a triangulation of 'environmental influences, personal factors and attributes of the behaviour itself' (Ozmete and Hira 2011: 391) which affect behaviour change. In a reciprocal way, all three can affect each other and be affected by each other, although not necessarily in equal strength (Bandura 1989).

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Looking at the P-B link, attitude, intentions, beliefs, expectations and emotions can affect behaviour. With the E-P link, the environment / social influences influence our expectations, intentions, beliefs, and emotions. Physical characteristics such as race, age, gender can also influence one's reactions to a social environment. Their status, financial or social can also create differing reactions. 'Thus, by their social status and observable characteristics people can affect their social environment before they say or do anything' (Bandura 1989: 4). In the B-E link, one's behaviour can affect the environment one is in, which can then alter one's behaviour, so an outwardly aggressive person can create an environment of stress, anger, emotional intensity which might cause people to leave that area, in turn leaving the aggressive person with no one to listen to them. The environment is not an unchanging entity, it affects people and people affect it. Looking at the physical environment, people create lots of CO_2 in their everyday lives, but it causes negative impacts upon the environment in terms of a changing climate, which then might affect people (Bandura 1989). Self-efficacy influences behaviour as it ascertains whether one will attempt the behaviour and if so, how much energy one will put into it (Darnton 2008a).

Self-efficacy can be increased or improved through various ways from skills training to modelling behaviour (Ozmete and Hira 2011). Resources and support can also help increase self-efficacy (Communication for Governance and Accountability Program (CommGAP) 2009). It can also be promoted with effective communication; however, the communication needs to appear achievable and seen as coming from a trusted source (Government Communication Network and Central Office of Information 2009).

Adapting and changing behaviour to advert climate change can be hindered by a lack of self efficacy in that the problem is too big for one person to make a difference (Government Communication Network and Central Office of Information 2009). However, in using SCT to promote agricultural behavioural change, a farmer's level of self-efficacy could be assessed, and by looking at the external environmental influences which might influence how farmers farm over the years such as finance, or tradition, or the local community, one could determine where to focus an intervention.

The Transtheoretical Model of Behaviour Change/ Stages of Change (TTM)

This was traditionally used to change unhealthy behaviour such as smoking into healthy behaviour (Ozmete and Hira 2011: 387). Darnton points out that TTM is essentially a segmentation model, which depending on the level of behaviour a person shows, arranges them on a scale which goes from pre-contemplation to termination (Darnton 2008a).

> Pre-contemplation – people have no intention of changing behaviour at present (up to six months).
>
> Contemplation – People feel they need to take action and change their behaviour, but are not yet ready to begin.
>
> Preparation – Action is imminent, plans of action may be created, some behaviour change may have already occurred.
>
> Action – Outwardly noticeable changes are made to a person's behaviour.
>
> Maintenance – Where the person works to prevent relapses of behaviour.
>
> Termination – the behaviour is now fixed and there is high self-efficacy that no relapse will occur (Government Communication Network and Central Office of Information 2009).

Darnton shows the model above as a cycle from pre-contemplation to maintenance where if people relapse they can go around again, however with termination as a final off shoot from maintenance where it is unlikely for a relapse to occur (Darnton 2008a: 42). Depending on the level of self-efficacy that a person is showing, it is possible to determine where they are on the model. Interventions can then be targeted at the level which the person is at. The COI point out that people in the contemplation stage are at a good stage for targeted communication about a relevant behaviour change (Government Communication Network and Central Office of Information 2009).

There are various critics of the model including Bandura himself, who ‘described it as “over-differentiated”, arguing that the first three stages (preceding action) only varied in terms of intention, while the next two stages (before termination) could only be measured by their duration)’ (Darnton 2008a: 43). Others argue that interventions can work at any level of the model, not just the latter levels (Government Communication Network and Central Office of Information 2009).

Using TTM to change behaviour in agriculture, one would need to discern which level the farmers were at and direct interventions specifically at those levels (Communication for Governance and Accountability Program (CommGAP) 2009). The authors go on to state that people may get stuck at early levels, with no motivation to move further on without intervention, but looking at the six levels, one could assume a farmer who had acknowledged that their farm might benefit from a more sustainable approach would be in the contemplation stage and by applying interventions such as advice and support, the farmer might move along to the preparation stage if not the action stage.

The Theory of Interpersonal Behaviour (TIB)

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Figure A1.2 adapted from (Jackson 2005: 94)

This includes habit as a factor, which is missed off the TPB model, habit being behaviour repeated so often it is unconscious or automatic. The model also recognises the influence of emotions – 'affect' (Darnton 2008b, Government Communication Network and Central Office of Information 2009). 'The inclusion of affect as a unique factor in the TIB is relatively unusual as most social-psychological models embed emotions within other components' (Darnton 2008b: 14).

Using this model, habit is more likely to influence behaviour ahead of intention and 'the more we repeat a particular behaviour, the more automatic it becomes. As time passes and the behaviour is undertaken more and more frequently, habit can therefore become the key factor driving behaviour' (Government Communication Network and Central Office of Information 2009: 17).

Habit can lead to routine - the more a behaviour is repeated, the more it becomes a routine, for example planting at a certain time. Hence as the behaviour is repeated over and over, habit drives the behaviour (Government Communication Network and Central Office of Information 2009). Kurt Lewin's theories of change suggests that to break habits, stirring up an emotional response is required (Lewin 1951) and 'for a newly changed behaviour to become refrozen into a habit, the *'whole social field'* will need to be adjusted' (Darnton 2008a: 40)(Darnton 2008a, p.40).
For agricultural behavioural change, using the TIB model, discovering farmers' habits would help understand why their behaviour may not change. An intervention could then work either around that habit or to adapt the habit to make a new one.

A1.1.2 Applied behaviour approaches

Social Marketing Theory (SMT)

SMT is about marketing the product in such a way to make individuals buy into it (and thus change their behaviour). It can also include incentives and benefits (Ozmete and Hira 2001).
It is often used by the UK government when using initiatives to change public behaviour (Darnton 2008a). Social marketing often uses multiple models, theories and instruments combined in an intervention and 'is multidisciplinary, and explicitly transtheoretical' (Darnton 2008a, P.57).

DEFRA has shown interest in behavioural change and specifically social marketing for many years, and in 2010, they requested a segmentation report, by behavioural type, of farmers (Barnes et al. 2010). This is discussed more in Chapter 2 of the thesis, so is not discussed in this appendix.

4e's diagram

This model was developed from Defra's work on pro-environmental behaviour, evolving out of their work with social marketing (Darnton 2008a) and segmenting the population of England for pro-environmental behaviour (Behaviours Unit DEFRA and Defra 2008) and using persuasive language such as enable, engage, exemplify, and encourage, to address both internal and external barriers to change (Pike 2008).

Some materials have been removed due to 3rd party copyright. The unabridged version can be viewed in Lancester Library - Coventry University.

Figure A1.3 adapted from (Behaviours Unit DEFRA and Defra 2008: 53)

Using incentives and disincentives to encourage, providing infrastructure to enable, influencing individuals underlying motivations and attitudes to engage and ensure the government exemplifies positive environmental behaviour such as buying produce locally (Pike 2008).

However the model does have some negative points as Darnton explains, being a policy development tool instead of a specific behavioural model, and not including many factors that can influence society's behaviour, such as the economy and market forces, other government policies and 'most obviously, sociopsychological factors are also omitted; it would be necessary to use the 4Es model alongside relevant behavioural models to determine which policy instruments were most likely to achieve an effective balance' (Darnton 2008a: 61).

Both Pike and Darnton differentiate between the theories and models, Pike by noting the distinction between 'those academic models that focus on predicting behaviours and those that focus on influencing behaviours' (Pike 2008: 6), and Darnton by stating: 'Models of behaviour help us to understand specific behaviours, by identifying the underlying factors which influence them. By contrast, theories of change show how behaviours change over time, and can be changed. The two bodies of theory are complementary; understanding both is necessary in order to develop effective approaches to behaviour change'(2008b: 11). They should be used together, working intertwined with the behavioural models sitting embedded inside the processes of intervention which have been created by the theories of change (Darnton 2008b). However, Darnton also cautions, that each theory and model generally has a different purpose and points out that there are disadvantages to using them and they need to be used carefully if they are to work correctly and achieve the results required (2008b).

A1.2 Existing agricultural interventions

> ***These examples of interventions below were used to help develop the Phase 1 survey question with regards to environmental schemes, but by the time of writing up this thesis some of them no longer existed (such as Co-Operative Farms (Co-operative Group Limited 2014)) or were as relevant to the research. As a result, this section still remains as written in 2011, rather than having been updated to join the main body of literature in Chapter 2 and is included here to help explain the choice in questions for the Phase 1 survey.***

Some of the longer run projects below are supported by commercial enterprises such as Waitrose (Waitrose 2011) and Marks and Spencer (Marks & Spencer PLC 2011).

'Ecoagriculture explicitly recognizes the economic and ecological relationships and mutual interdependence among agriculture, biodiversity and ecosystem services.... Ecoagriculture landscapes are mosaics of areas in natural/native habitat and areas under agricultural production. Effective ecoagriculture systems rely on maximizing the ecological, economic and social synergies among them, and minimizing the conflicts' (Scherr and McNeely 2008: 480).

Another sustainable agricultural initiative is LEAF. 'LEAF (Linking Environment And Farming) was established... to promote environmentally responsible farming across the UK. LEAF's approach is built around promoting the whole-farm approach of Integrated Farm Management (IFM), which seeks to achieve a balance between adopting the best of modern technology and maintaining sound traditional methods, in order to enhance the environment through responsible farming' (Mills et al. 2010: 1).

The Co-Operative Farms currently consist of fourteen farms across England and Scotland; however, they also offer various client services to farmers from advice to partnerships. Each farm and the whole project is committed to farming sustainably and caring for the environment and the local communities and they encourage schools to visit to learn about where animals and food come from (The Co-operative Farms 2011a). They are also pushing forward their sustainable farming with research and development including 'evaluating a tractor cab mounted nitrogen sensor which predicts the nitrogen needs in a crop by measuring the crop biomass. It then adjusts application rates accordingly, in real time, as the tractor and spreader is moving through the crop. This application method improves the efficiency of use of nitrogen within the field' (The Co-operative Farms 2011b).

As part of National Trust properties and land across the UK (250,000 hectares), the charity rents the attached farmland (80% of the land) (National Trust 2015a). As the charity encourages the farmers to farm responsibly and sustainably where possible, this means that the land that is farmed organically is higher than the national average (7% instead of 4%) (National Trust 2015b). Recently, the National Trust launched *My Farm*, which encourages people to pay £30 to become a 'virtual' farmer on the Wimpole farm in Cambridgeshire. Those subscribing can take part in deciding on what to grow, how to treat the animals and get a free family ticket to visit the farm if they are ever near Letchworth. The farm has just finished converting to become organic and the hope is 10,000 people will subscribe and take part in learning about how an actual farm works (National Trust 2011).

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Appendix 2- Assessment and analysis of potential stakeholders from the research design element of the study.

Table A2 showing potential stakeholders who might have interests in the environment, agroecology and sustainable farming.

Stakeholders	Interests	Environmental concerns.
Primary Stakeholders – those with a direct interest in farming, are most likely to be affected and have direct influence in making changes.		
Farm employees with managerial roles	Income, farming, animal / crop health/viability.	Yes, if the environmental changes influence animals/crops, farming practices or income.
Farmer - tenants	Income, farming, legal matters relating to tenancy and farm, tax issues including paying employees/ contractors, animal/crop health/viability, machinery upkeep, animal feed costs, etc.	Yes, if the environmental changes influence animals/crops, farming practices or income. Also, where environmental legislation influences farming. Yes, if agricultural diesel increases in price, or becomes less available.
Farmers – land owners	Income, farming, legal matters relating to farm, tax issues including paying employees/ contractors, animal/crop health/viability, machinery upkeep, animal feed costs, etc.	Yes, if the environmental changes influence animals/crops, farming practices or income. Also, where environmental legislation influences farming. Yes, if agricultural diesel increases in price, or becomes less available.
Farm managers	Income, farming, legal matters relating to farm, tax issues including paying employees/ contractors, staff contracts, animal/crop health/viability,	Yes, if the environmental changes influence animals/crops, farming practices or income. Also, where environmental legislation

Stakeholders	Interests	Environmental concerns.
	machinery upkeep, animal feed costs, etc.	influences farming. Yes, if agricultural diesel increases in price, or becomes less available.
Farm estate owners (E.g. National Trust, Prince of Wales, Universities)	Income, legal matters relating to farm, tax issues regarding renting, tenancy contracts, potential environmental interests.	Yes, if the environmental changes influence farming practices or income. If environmental interests, probably due to environmental concern.
Female employees, farmers, managers and owners as Wilson et. al (2011) stated that only 5% of those completing the farm business survey were women, whilst DEFRA and the National Statistics (2015) assessed that in 2013 only 16% of females owned their farms and only 17% were managers.	All of the above, possibly interests from a gender perspective.	All of the above, possibly interests from a gender perspective.
Secondary Stakeholders – those who may be indirectly affected, and benefit from farming, but do not necessarily make direct changes or have direct influence.		
Farm employees without managerial roles (possibly female)	Income, farming, animal / crop health/viability.	Yes, if the environmental changes influence animals/crops, farming practices or income.

Stakeholders	Interests	Environmental concerns.
Contractors (possibly female)	Income, machinery upkeep, probably farming, self-assessment for tax.	Yes, if the environmental changes influence farming practices or income. In addition, if environmental legislation were to impact on machinery, or fuel costs were to become too high.
Agricultural advisors	Income from sale of products, farm products, animal /crop health/machinery maintenance, potential environmental interests? Government / EU legislation, advice to farmers.	Less likely, but yes if the environmental changes influence animals/crops, farming practices or income. Also, where environmental legislation influences farming. Also, yes if having environmental interests and general concerns.
Vets	Animal health, income, government / EU legislation, advice to farmers.	Less likely, but yes if the environmental changes impact on animals, animal feed.
NFU representatives, NFU	Animal /crop health/machinery maintenance, potential environmental interests? Government / EU legislation, advice to farmers, income from union fees.	Yes, if the environmental changes influence animals/crops, farming practices or income. Also, where environmental legislation influences farming. Yes, if agricultural diesel increases in price, or becomes less available. Also, possibly, influence food security?
Local small retailers	Goods from farms, therefore loosely interest in animal / health issues, environmental issues, income from sale of	If environmental interests, probably due to environmental concern. Also, yes if the environmental changes impact

Stakeholders	Interests	Environmental concerns.
	goods, tax/legislation requirements.	on animals/crops, farming practices or income. Also, where environmental legislation influences farming.
Independent middlemen – processing plants, slaughterhouses, mills etc.	Goods from farms, therefore loosely interest in animal / health issues, income from sale of goods, tax/legislation requirements, health and safety.	Loosely yes if the environmental changes influence animals/crops, farming practices or income.
External stakeholders – Those who may have some direct influence, and create positive and negative effects on farming, but also overarching influence on the agriculture sector		
Supermarkets	Income, supply from farms and middlemen, (depending on ethics vs profitability of supermarket, possibly environmental issues), provenance, tax/legislation etc.	Less so, but yes if ethics of supermarket (e.g. M&S) encourage environmental interests and concerns. Yes, where environmental change influences food security, and if fuel costs increase.
Media	Income, reporting important / good stories, popularity, (possible environmental/ human interest if more ethical).	Yes, if there is a story – food security, food prices, or if people pushing the media have environmental concerns and want to highlight them.
Consumers	Cost, flavour, availability, (regional, local, environmental and ethical issues for some consumers), provenance.	Less so, but definitely yes if food costs or food security become an issue. Also, yes, if ethical and environmental issues are of interest / concern to consumers.
UK Government advisors, ministers, DEFRA, APPG in agroecology	Food security, environment, animal / crop health, votes, tax/legislation, (interests of financial supporters?)	Yes, food security, climate change, environmental change and impacts on farming.

Stakeholders	Interests	Environmental concerns.
EU	Food security, environment, animal/crop health, tax/legislation, (potential interests of financial supporters?)	Yes, food security, climate change, environmental change and impacts on farming.

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Appendix 3 – ethics approval for pilot (P3702), Phase 1 (P15984) and Phase 2 (P33353)

REGISTRY RESEARCH UNIT: ETHICS REVIEW FEEDBACK FORM

Name of applicant: Katie Hartless ....

Faculty/School/Department: [Student Services] SS Careers and Employability

....

Research project title: Pilot survey. Building resilient farming communities in the UK. Exploring sustainable behaviour change on UK farms in relation to climate change. **Project: 3702**

Comments by the reviewer

1. Evaluation of the ethics of the proposal: see comments	
2. Evaluation of the participant information sheet and consent form: see comments	
3. Recommendation: (Please indicate as appropriate and advise on any conditions. If there any conditions, the applicant will be required to resubmit his/her application and this will be sent to the same reviewer).	
X	Approved - no conditions attached
	Approved with minor conditions (no need to re-submit)
	Conditional upon the following – please use additional sheets if necessary (please re-submit application)
	Rejected for the following reason(s) – please use other side if necessary
	Not required

Name of reviewer: Anonymous..

Date: 08/02/2012..

REGISTRY RESEARCH UNIT: ETHICS REVIEW FEEDBACK FORM

(Review feedback should be completed within 10 working days)

Name of applicant: Katharine Hartless Rose.................

Faculty/School/Department: [Business, Environment and Society] Geography, Environment & Disaster Manager ....

Research project title: PhD full survey – Phase 1. Project: **P15984**

Comments by the reviewer

4. Evaluation of the ethics of the proposal: All complete and issues explained
5. Evaluation of the participant information sheet and consent form: Complete
6. Recommendation: (Please indicate as appropriate and advise on any conditions. If there any conditions, the applicant will be required to resubmit his/her application and this will be sent to the same reviewer).

X	Approved - no conditions attached
	Approved with minor conditions (no need to re-submit)
	Conditional upon the following – please use additional sheets if necessary (please re-submit application)
	Rejected for the following reason(s) – please use other side if necessary
	Not required

Name of reviewer: Anonymous..

Date: 04/09/2013..

Phase 2 ethics approval. Project: P33353

REGISTRY RESEARCH UNIT

ETHICS REVIEW FEEDBACK FORM

(Review feedback should be completed within 10 working days)

Name of applicant: Katharine Hartless Rose..................

Faculty/School/Department: [University Research Centre] Centre for Agroecology, Water and Resilience

Research project title: Phase 2 data collection Regenerative Agriculture UK

Comments by the reviewer

1. Evaluation of the ethics of the proposal:

This is a very clear and comprehensive ethical evaluation, which outlines all the associated risks and ethical issues likely to be encountered during field work. It also presents clear strategies for minimising risks and for ensuring data protection protocols are followed.

2. Evaluation of the participant information sheet and consent form:

The participant information sheet provides a clear explanation of the purpose of the research and outlines in detail how the information collected will be used. The form also seeks consent for a variety of different aspects to the research and makes a useful distinction between those participants who are willing to attribute their names to quotes and those who would wish to remain anonymous.

3. Recommendation:

(Please indicate as appropriate and advise on any conditions. If there any conditions, the applicant will be required to resubmit his/her application and this will be sent to the same reviewer).

X	Approved - no conditions attached
	Approved with minor conditions (no need to re-submit)
	Conditional upon the following – please use additional sheets if necessary (please re-submit application)
	Rejected for the following reason(s) – please use other side if necessary
	Not required

Name of reviewer: Anonymous...

Date: 22/05/2015...

Appendix 4 – Phase 1 participant information sheet and consent form

Participant information Sheet
Are you confident that your farm is resilient to climate change or anything the weather throws at you?

Building resilient farming communities in the UK.
Exploring sustainable farming on UK farms in relation to climate change.

BY ANSWERING MY QUESTIONS, YOU ARE CONSENTING TO YOUR DATA BEING USED IN THIS STUDY. INFORMATION WILL REMAIN CONFIDENTIAL AND ANONYMOUS, UNLESS YOU PERMIT ME TO PUT YOUR NAME AGAINST SELECTED QUOTATIONS.

PURPOSE OF THE RESEARCH

This survey is to help me to begin to understand your situation and is the first step in my PhD studies at Coventry University. The results will be useful to the farming community, as they will show the challenges you and other farmers face. The results may also help inform government policy.

PARTICIPATION IN THIS RESEARCH WILL INVOLVE

If you take part in this study, you can complete the questions in the survey either by replying to the email, or through clicking the link to do the survey online. I can also post out the survey to you with a return address envelope, if you would prefer. If you chose to leave your name and farm details, then I can get in contact with you for further research next year following up on the survey results.

BENEFITS TO THE PARTICIPANT OF PARTICIPATION

The results of the survey can be sent to interested farmers, and where farmers have agreed to be identified, it may create peer learning of successful and unsuccessful sustainable farming.

WILL MY TAKING PART IN THIS STUDY BE KEPT CONFIDENTIAL?

If you request for your data to be kept confidential, then I will not use anything that could identify you or your farm and it will remain anonymous. If however, you are happy to share your knowledge and experience in farming sustainably (successfully or unsuccessfully), then I will use the information you provide to inform both my study, any journals or farming magazines that publish my work and form part of the report to send out to participants who indicate interest.

WHAT WILL HAPPEN TO THE RESULTS OF THE RESEARCH STUDY?

The results of the research will form part of my PhD study and inform the direction of any future research, which will take place.

If you have any questions or queries, Katie Hartless Rose will be happy to answer them.

If you have any questions about your rights as a participant or feel you have been placed at risk, you can contact Katie on 024 7615 2036 or katie.hartlessrose@coventry.ac.uk

Or my Director of Studies: Julia Wright - julia.wright@coventry.ac.uk

Informed Consent Form
Are you confident that your farm is resilient to climate change or anything the weather throws at you?

Building resilient farming communities in the UK. Exploring sustainable farming on UK farms in relation to climate change.

This survey is to help me to begin to understand your situation and is the first step in my PhD studies at Coventry University. The results will be useful to the farming community, as they will show the challenges you and other farmers face. The results may also help inform government policy.

Please initial

1. I confirm that I have read and understood the participant information sheet for the above study and have had the opportunity to ask questions ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason ☐

3. I understand that all the information I provide will be treated in confidence ☐

4. I understand that I also have the right to change my mind about participating in the study for a short period after the study has concluded (insert deadline here) ☐

5a. I agree for quotes to be used as part of the research project. I agree to my name being included with relevant quotes. ☐

OR

5b. I agree for anonymised quotes to be used as part of the research project. I do not allow my name to be attributed to any quotes used. ☐

6. I agree to take part in the research project

Name of participant: ....

Signature of participant: ....

Date: ....

Name of Researcher: Katie Hartless Rose...

Signature of researcher: ....

Date: ....

Appendix 5 – Phase 1 survey

Are you confident that your farm is resilient to climate change or anything the weather throws at you?

Coming from a family farming background in Herefordshire, I have a keen interest that you and the UK farming community will be able to continue farming throughout a changing climate and any reductions in availability of fossil fuels.

This survey is to help me to begin to understand your situation and is the first step in my PhD studies at Coventry University.

You can be sent the results, which show the challenges you and other farmers face. The results will also help inform government policy.

If you are short of time, just tick the boxes, it should take you approximately 10 minutes to complete. If you have more time, please respond more fully.

NB questions 1 and 2 are participant consent questions on the online form, please see the attached participant consent form for these questions.

About you and your farm...

3. Please fill in your name, address, email / website (optional):

____

____

____

4. Which region do you farm? (Please give the first part of your postcode)

_____ XXX

5. What sector(s) do you farm? (Please tick one or more boxes)

Arable Crops ☐

Horticulture (vegetable crops including potatoes, perennial and protected cropping) ☐

Dairy ☐

Beef ☐

Sheep ☐

Pigs ☐

Poultry ☐

Hill farming ☐

Organic certification ☐

Farm diversification, please state

____

Any other, please state ____

6. Please indicate your gross turnover bracket 1000'(k) £ per year (Tick one box)

Under £20k ☐

£20k-£40k ☐

£40k-£100k ☐

£100k-£500k ☐

Over £500k ☐

7. Please indicate the size of your farm (Tick one box)

Under 20 hectares ☐

20 - 40 ha ☐

40 - 100 ha ☐

100 - 200 ha ☐

200 - 500 ha ☐

Over 500 ha ☐

8. Do you own or rent your farm, if both please give a rough proportion of owned and rented? (Tick one or more boxes)

Own ☐

Rent ☐

If both Click here to enter text. ____% owned and Click here to enter text. ____% rented.

9. Are you in an environmental rated scheme?

Yes / No

If yes, please tick all that apply:

Defra's environmental stewardship schemes e.g. ELS, OELS, HLS ☐ (please specify Click here to enter text.)

Supermarket scheme (e.g. Cooperative Farms or M&S) ☐

LEAF marquee ☐

Freedom Food ☐

Certified Organic farming (e.g Soil Association, OF&G, OFF) ☐

Certified biodynamic ☐

Soil Association's Low Carbon Farming project ☐

Permaculture network ☐

Other environmental/sustainability scheme ☐ Click here to enter text.

No scheme ☐

Thoughts on environmental issues and climate change impacts on your farm

10. Do you know the carbon footprint of your farm or an individual enterprise on your farm?

Yes / No

If yes, what is it and how did you find this out?

____

11. Compared to 30 years ago, do you feel your farm is experiencing unusual levels of agronomic impact from changing weather on farming in terms of?

Impact	a) Experiencing impact from changing weather	b) If yes, please describe	c) Do you feel you have it under control
Water shortages - piped water	Yes / No		Yes / No
Water shortages - Rain water	Yes / No		Yes / No
Water Shortages – lower river levels	Yes / No		Yes / No
Increased Flooding	Yes / No		Yes / No
Increased pests, diseases and weeds	Yes / No		Yes / No
Top soil loss	Yes / No		Yes / No
Crop failures	Yes / No		Yes / No
Any other impacts of changing weather on your business?	Yes / No		Yes / No

12. Do you have any evidence of this / have you recorded it?

Yes / No

If yes, and you are happy to share it, please could you send it to me at

katie.hartlessrose@coventry.ac.uk

13. Where do you go for help with dealing with the above issues?(Tick all that apply)

Where do you go (tick one or more boxes)	How useful on a scale of 1-10 (with 10 being very useful)?	Do you feel sufficiently informed from the help that you gained to address the problem?	Has the help worked?	Why do you use this source for help?
Friends / Family / Neighbours. ☐		Yes / No	Yes / No	
Written publications E.g. newspapers. ☐		Yes / No	Yes / No	
Specialist advisors. ☐		Yes / No	Yes / No	
Other ☐ ______		Yes / No	Yes / No	

14. Long term planning is required to combat climate change. Are you able to factor this into your business plan for the next five years? Yes / No

How do you factor it in? (Please tick one or more boxes)

Allocated money ☐

Allocated time ☐

Thought about it, but not allocated anything yet ☐

Other resources ☐ ____

Evidence shows that certain agricultural techniques help to mitigate against climate change...

15. Are you using any of the following sustainable agricultural techniques on a regular basis, or over a significant area of your farm?

Techniques	Using the techniques?	For how long?	How large an area?	If not, why not? *Please delete those not appropriate below.*	Would you like to know more?
Environmental management techniques for dealing with bulk manure to prevent leaching and emissions?	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm / If other, please describe	Yes / No
Renewable energy schemes such as wind turbines, biomass boilers, photovoltaic panels, biodiesel?	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm / If other, please describe	Yes / No
Collecting and conserving rainwater?	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm / If other, please describe	Yes / No

Grazing management	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm / If other, please describe	Yes / No
Energy reduction techniques, such as reducing the use of the tractor, reducing emissions in processing, or different transport beyond the farm gate?	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm / If other, please describe	Yes / No

16. Are you doing any of the following techniques to capture greenhouse gases (carbon dioxide etc.) in soil, aerate soil or increase water retention in soil such as:

Techniques	Using the techniques?	For how long?	How large an area?	If not, why not? *Please delete those not appropriate below.*	Would you like to know more?
Zero / Minimum tillage, or other ways to capture greenhouse gases by minimising soil disturbance?	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm / If other, please describe	Yes / No
Intentionally sowing deeper rooting plants?	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm. If other, please describe	Yes / No

Maintaining permanent soil cover, such as using cover crops (e.g. red clover)?	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm. If other, please describe	Yes / No
Converting strips of land at edges of field back to coppices, hedging, grasslands, or wetlands?	Yes / No			Too expensive / what is this, I haven't heard about it / did use it but it wasn't successful / not interested / don't feel it will work on my farm. If other, please describe	Yes / No

17. a) If suitable, please describe a successful method that you have found for dealing with any of the above?

____

____

____

____

____

____

Would you be happy to be a case study?

Yes / No

18. In general, what do you feel are other major constraints hindering you from farming in a more climate friendly fashion? (tick all that are relevant)

Knowledge☐

Finance to implement changes ☐

Not interested ☐

Time required for change vs finance loss ☐

A later stage of this study would include a workshop (lunch included).

Would you like further contact?

Yes / No

(if yes, please leave your details).

____
____

____
____

Many thanks for filling in my survey

Katie Hartless Rose

katie.hartlessrose@coventry.ac.uk

Appendix 6

Participant information Sheet – Phase 1 participants

Building resilient farming communities in the UK. Exploring sustainable farming on UK farms in relation to climate change.

BY ANSWERING MY QUESTIONS ON THE CONSENT FORM, YOU ARE CONSENTING TO YOUR DATA BEING USED IN THIS STUDY. INFORMATION WILL REMAIN CONFIDENTIAL AND ANONYMOUS, UNLESS YOU PERMIT ME TO PUT YOUR NAME AGAINST SELECTED QUOTATIONS.

Purpose of the Research

This research is part of my PhD studies to understand farming techniques in the UK that may improve farming chances against any climate impacts. The results will be useful to the farming community, as they will show the challenges you and other farmers face. The results may also help inform government policy.

Why have I been chosen?

For this research I am contacting farmers who answered my phase 1 survey and expressed an interest in taking part in further research.

Do I have to take part?

No, participation is voluntary. You do not have to take part in any part of this study.

What do I have to do?

If you take part in this study, you will be invited to participate in either individual or group interviews (or both), which will form 'case studies'. They will give you the opportunity to give your thoughts and experiences on sustainable agriculture techniques and training courses you may have attended. These 'interviews' will be recorded in writing and through audio recording by a researcher and will be used to assist in the writing of the report. All interviews will be anonymous, but you will have an opportunity to consent to your name being used against quotations.

What are the risks associated with this project?

It is not anticipated that there would be any risks associated with this project apart from possibly taking time out of your day, but I would attempt to arrange the interview to suit your schedule.

What are the benefits of taking part?

The interviews are an opportunity for you to share your viewpoints about your experiences of sustainable farming techniques, training courses which have helped or hindered your understanding of those techniques and In addition, where farmers have agreed to be identified, it may create peer learning of successful and unsuccessful sustainable farming.

Withdrawal options

You can chose to withdraw at any point during the sessions and you can withdraw up until the end of the study (end of March 2016) by contacting me below. Your data will be destroyed if you choose to withdraw, and there will be no consequences.

Data protection & confidentiality

If you request for your data to be kept confidential, then I will not use anything that could identify you or your farm and it will remain anonymous. If however, you are happy to share your knowledge and experience in farming sustainably (successfully or unsuccessfully), then I will use the information you provide to inform both my study, and any journals or farming magazines that publish my work.

What if things go wrong?

If I have to cancel an interview, I will attempt to contact you as soon as possible using the method you have indicated in our communication, and as mentioned above if you change your mind about taking part, you can withdraw until the beginning of March 2016.

If you need to re-arrange an interview with me, please could you attempt to contact me using the details below as soon as possible to avoid unnecessary travel.

What will happen with the results of the study?

The results of the research will be analysed and written up to form the major part of my PhD study.

Who has reviewed this study?

This study has been through the Coventry University Ethics review process and has been approved.

Further information/Key contact details

If you have any questions or queries, Katie Hartless Rose will be happy to answer them.

If you have any questions about your rights as a participant or feel you have been placed at risk, you can contact Katie on 024 7615 2036 or katie.hartlessrose@coventry.ac.uk

Or my Director of Studies: Julia Wright - julia.wright@coventry.ac.uk

Participant information Sheet – Phase 2 participants only

Building resilient farming communities in the UK. Exploring sustainable farming on UK farms in relation to climate change.

BY ANSWERING MY QUESTIONS ON THE CONSENT FORM, YOU ARE CONSENTING TO YOUR DATA BEING USED IN THIS STUDY. INFORMATION WILL REMAIN CONFIDENTIAL AND ANONYMOUS, UNLESS YOU PERMIT ME TO PUT YOUR NAME AGAINST SELECTED QUOTATIONS.

Purpose of the Research

This research is part of my PhD studies to understand farming techniques in the UK that may improve farming chances against any climate impacts. The results will be useful to the farming community, as they will show the challenges you and other farmers face. The results may also help inform government policy.

Why have I been chosen?

For this research I need to recruit farmers who have attended Regenerative Agriculture UK (RegenAG UK) workshops. It does not matter how long ago you attended a workshop, you will still be eligible.

Do I have to take part?

No, participation is voluntary. You do not have to take part in any part of this study.

What do I have to do?

If you take part in this study, you will be invited to participate in either individual or group interviews (or both), which will form 'case studies'. They will give you the opportunity to give your thoughts and experiences on Regenerative Agriculture and other sustainable agriculture techniques. These 'interviews' will be recorded in writing and through audio recording by a researcher and will be used to assist in the writing of the report. All interviews will be anonymous, but you will have an opportunity to consent to your name being used against quotations.

What are the risks associated with this project?

It is not anticipated that there would be any risks associated with this project apart from possibly taking time out of your day, but I would attempt to arrange the interview to suit your schedule.

What are the benefits of taking part?

The interviews are an opportunity for you to share your viewpoints about the project, which may help increase RegenAG UK's reach to other farmers and improve their chances of receiving grants from organisations. In addition, where farmers have agreed to be identified, it may create peer learning of successful and unsuccessful sustainable farming.

Withdrawal options

You can chose to withdraw at any point during the sessions and you can withdraw up until the end of the study (beginning of March 2016) by contacting me below. Your data will be destroyed if you choose to withdraw, and there will be no consequences.

Data protection & confidentiality

If you request for your data to be kept confidential, then I will not use anything that could identify you or your farm and it will remain anonymous. If however, you are happy to share your knowledge and experience in farming sustainably (successfully or unsuccessfully), then I will use the information you provide to inform both my study, any journals or farming magazines that publish my work and form part of the report to sent out to Regenerative Agriculture UK.

What if things go wrong?

If I have to cancel an interview, I will attempt to contact you as soon as possible using the method you have indicated in our communication, and as mentioned above if you change your mind about taking part, you can withdraw until the beginning of March 2016.

If you need to re-arrange an interview with me, please could you attempt to contact me using the details below as soon as possible to avoid unnecessary travel.

What will happen with the results of the study?

The results of the research will be analysed and written up to form the major part of my PhD study. They may also be fed back in a report to RegenAG UK for use in funding bids.

Who has reviewed this study?

This study has been through the University Ethics review process and has been approved.

Further information/Key contact details

If you have any questions or queries, Katie Hartless Rose will be happy to answer them.

If you have any questions about your rights as a participant or feel you have been placed at risk, you can contact Katie on 024 7615 2036 or katie.hartlessrose@coventry.ac.uk

Or my Director of Studies: Julia Wright - julia.wright@coventry.ac.uk

Informed Consent Form

Building resilient farming communities in the UK. Exploring sustainable farming on UK farms in relation to climate change.

This research is part of my PhD studies to understand farming techniques in the UK that may improve farming chances against any climate impacts. The results will be useful to the farming community, as they will show the challenges you and other farmers face. The results may also help inform government policy.

Please initial

1. I confirm that I have read and understood the participant information sheet for the above study and have had the opportunity to ask questions ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason ☐

3. I understand that all the information I provide will be treated in confidence ☐

4. I understand that I also have the right to change my mind about participating in the study for a short period after the study has concluded (Beginning of March 2016) ☐

5a. I agree for quotes to be used as part of the research project. I agree to my name being included with relevant quotes. ☐

OR

5b. I agree for anonymised quotes to be used as part of the research project. I do not allow my name to be attributed to any quotes used. ☐

6a. I agree to the interview / focus group discussion being audio recorded ☐ ☐

AND

6b. I agree to photos being taken of my farm and used for research by CAWR where appropriate. The photos will not identify myself or my farm unless I have selected 5a above. ☐

7. I agree to take part in the research project

Name of participant: ……………………………………………………………………………

Signature of participant: ……………………………………………………………………

Date: ……………………………………………………………………………………………………

Name of Researcher: Katie Hartless Rose……………………………………………………

Signature of researcher: ………………………………………………………………………

Date: ……………………………………………………………………………………………………

Appendix 7 - Phase 2 questions for RegenAG UK and survey participants.

Phase 2 initial questions for RegenAG UK participants

A - Current attendees

Evaluation form (including demographics – age, sex, location, farm sector, environmental scheme beyond RegenAG, farm size / income?) – see other attachment.

Follow up conversation that could include:

1. Why did you sign up?
2. How did you find the training?
3. Have you begun to implement anything you learnt?
4. If so, how has that gone?
5. If not, why not?
6. Would you like any support to help you implement what you learnt?
7. Would you / have you share(d) your new knowledge with your peers?
8. Would you be interested in an online learning forum to share knowledge and learn from others?
9. Would you be interested in meeting up with other RegenAG UK members for a social over the winter 2015-16?
10. Any climate questions?

B - Current alumni

Asking:

1. What courses do you generally like to attend?
2. What kind of follow up support would you have liked after each course?
3. Have you had any constraints or successes in implementing what you learnt?
4. If so, are you willing to share that?
5. If you have not attempted to implement what you learnt, would you be willing to share why not?
6. Have you shared your knowledge with your peers and colleagues?

7. Has that reaped any interest?
8. Would you be interested in an online learning forum to share knowledge and learn from others?
9. Would you be interested in meeting up with other RegenAG UK members for a social over the winter 2015-16?
10. Any climate questions?
11. Would you like more in-depth workshops that follow-on from the introductory workshop?

C - Longer-term alumni

Questions could include:

1. Did you take part in any learning groups after attending a workshop?
2. Is the group still running?
3. If not, any idea why not?
4. Is it something that RegenAG UK could help support and if so, how?
5. What was the nature of the courses you attended?
6. Did you apply what you had learnt and if so how?
7. If not, why not?
8. To what extent / would you have liked follow up support?
9. Would you be interested in meeting up with other RegenAG UK members for a social over the winter 2015-16?
10. Any climate questions?
11. Have you shared your knowledge with your peers and colleagues?
12. Has that reaped any interest?
13. Are you willing to share why you no longer attend workshops with RegenAG UK?

These questions are already approved for ethics as they were submitted as part of the ethics for phase 2 entitled RegenAG UK participants. They have just been edited to remove all the specific RegenAG UK questions from the list for Phase 1 participants.

1. Can you please tell your role here? …. Follow up on what they say.
2. Have you experienced any impacts on your farm / plot that may be related to changing weather /[97] climate (e.g. water shortages, flooding…)?
3. What made you change start to farm more climate friendly / sustainably?
4. What courses / events / groups do you generally like to attend that can help you farm sustainably/ environmentally friendly/ climate friendly?
5. What was the nature of the courses? *(were the workshops you attended introductory?)* e.g. soil, energy usage, mob grazing, green manures, water.
6. Have you heard about Regenag / HMI / perma courses?
7. Where there any barriers (for instance cost) which hindered you attending a course?
8. What kind of follow up support would you have liked after each course?
9. Would you have liked a more in-depth workshop to follow-on from the introductory workshop you attended (if they were introductory)?
10. Do you learn from other farmers?
11. Have you begun to implement to apply anything that you learnt on those courses?
12. Questions about soil, mob grazing (size of pasture, rotations, water, flerds)…from question 11.
13. If so, how has that gone? Are you willing to share constraints and/or successes in implementing that learning?
14. If you have not attempted to implement what you learnt, would you be willing to share why not? (Constraints and/or successes in implementing learning).

[97] Using the slash (/) allows various options in the question to be printed to aid with the interviews, and tailored to the interviewee.

15. Would you / have you share(d) your knowledge with your peers and colleagues?
16. Has that reaped any interest?
17. Have you found farmers find it easier to understand the techniques you are doing by seeing it in action?
18. Can you think of anything in your area, which might persuade farmers to farm more agroecologically and sustainability?
19. Are you using any other sustainable farming techniques beyond what you learnt on the course?
20. Would you be interested in an online learning forum to share knowledge and learn from others, or are you already part of one?
21. Do you find social media such as AgrichatUK on Twitter, or TFF useful?
22. Would you be interested in attending a workshop on *constraints you* mentioned (q4-5)?
23. Any climate questions? *Including questions in response to their survey results. Animal health, soil, drought, flooding?*
24. Do you have anything further to add about the courses you've attended regarding how they may help others farm more sustainably?

Appendix 8- Further results from Phase 1 survey

Corresponding to 5.1.2 Farming sectors

Table A8.1 - Q5 farming sector combinations

Combination	No	Other/Diversification notes
Arable (+other/div)	4	Renewable Energy Cattle grazing (? Not sure what this means as the person who put this did not select beef or dairy) Light Industrial units Building one (although possibly two) 500kW wind turbine on the farm to provide an alternative revenue stream and to offset the farm's CO2 emissions.
Arable	2	
Arable and beef	3	
Arable, beef, sheep (+other/div)	2	Fattening Lambs
Arable, beef, sheep, organic	1	
Arable, dairy, beef, sheep (+other/div)	1	large HLS scheme
Arable, dairy, beef, sheep, hill	1	
Arable, dairy, beef, sheep, organic	1	
Arable, Horticulture, (+other/div)	1	Rented farm cottages Conservation
Arable, Horticulture, Organic (+other/div)	1	shop and cafe CSA
Arable, Horticulture, Sheep (+other/div)	1	glamping
Arable, sheep, poultry (+other/div)	1	Farmers Markets
Beef	3	
Beef and sheep (+other)	3	wildlife inc hedges
Beef, sheep and hill	2	
Beef, sheep, pigs and organic (+other/div)	1	We have a farm study centre and a wedding venue.
Beef, sheep, pigs, poultry and hill	1	
Dairy (+other/div)	3	solar windwater
Horticulture	2	

Horticulture and Organic (+other/div)	2	education relating to sustainability horticulture and the environment
Horticulture, beef, sheep, poultry, organic	1	Top and soft fruit agroforestry
Other	1	conacre rental of land for grazing and community growing use of farm and woodland for outdoor activities for health and well being
Sheep (+other)	2	goats, flowers
Sheep and poultry	1	
Sheep, pigs, poultry (+other/div)	1	Holiday cottage
Sheep, pigs, poultry, hill (+other/div)	1	Educational and care farming with a small residential unit fruit and veg gardens and a woodland
Total	43	

Corresponding to 5.2 Hazards, shocks, stresses and constraints that participant farmers are experiencing

Table A8.2 - Q11 – question grid.

Impact	**b) Experiencing impact from changing weather**	**b) If yes, please describe**	**c) Do you feel you have it under control**
Water shortages - piped water	Yes / No		Yes / No
Water shortages - Rain water	Yes / No		Yes / No
Water Shortages – lower river levels	Yes / No		Yes / No

Increased Flooding		Yes / No		Yes / No
Increased pests, diseases and weeds	Yes / No		Yes / No	
Top soil loss	Yes / No		Yes / No	
Crop failures	Yes / No		Yes / No	
Any other impacts of changing weather on your business?	Yes / No		Yes / No	

Corresponding to 5.3.1, the 2x2 table A8.3 for the flooding and recording evidence results.

Table A8-3 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for experiencing flooding and recording evidence of it.

			Do you have any evidence of this / have you recorded it?		
			yes	no	Total
Increased flooding? -- Experiencing impact from changing weather	yes	Count	10	12	22
		Expected Count	6.8	15.2	22.0
	no	Count	3	17	20
		Expected Count	6.2	13.8	20.0
Total		Count	13	29	42

Corresponding to 5.4.1, the 2x2 table A8.4 for organic farming and asking for advice from family and friends.

Table A8.4 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for farming organically and asking for advice from family and friends.

			Friends / Family / Neighbours -- Do you get help from these places?		
			yes	no	Total
Organic - what sector do you farm?	not selected	Count	25	11	36
			22.3	13.7	36.0
	selected	Count	1	5	6
		Expected Count	3.7	2.3	6.0
Total		Count	26	16	42
		Expected Count	26.0	16.0	42.0

Corresponding to 5.4.1, the 2x2 table A8.5 for those in a DEFRA scheme and using specialist advisors for help.

Table A8.5 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those under a DEFRA environmental scheme and those going to specialist advisors for help.

			Specialist advisors -- Do you get help from these places?		
			yes	no	Total
Defra's environmental stewardship schemes e.g. ELS, OELS, HLS (please list in the other box below)	not selected	Count	4	12	16
		Expected Count	8.9	7.1	16.0
	selected	Count	20	7	27
		Expected Count	15.1	11.9	27.0
Total		Count	24	19	43
		Expected Count	24.0	19.0	43.0

Corresponding to 5.4.2, the 2x2 table A8.6 for those who had allocated time in factoring in climate change impacts, and were converting strips of land.

Table A8.6 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those who factored climate change into their business plan by allocated time, and were converting strips of land back to nature

			Converting strips of land at edges of field back to coppices, hedging, grasslands, or wetlands? -- Using the techniques?		
			yes	no	Total
Allocated time	not selected	Count	14	16	30
		Expected Count	18.1	11.9	30.0
	selected	Count	12	1	13
		Expected Count	7.9	5.1	13.0
Total		Count	26	17	43
		Expected Count	26.0	17.0	43.0

Corresponding to 5.4.3 Agroecological Techniques

Q15-16 – question grid

Table A8.7 Q15

Please note the options for iv) 'if not why not' were: Too expensive; What is this, I haven't heard about it; Did use it but it wasn't successful; Not interested; Don't feel it will work on my farm; If other, please describe

Techniques	**i) Using the techniques?**	**ii) For how long?**	**iii) How large an area?**	**iv) If not, why not? *Select one option from list above***	**v) Would you like to know more?**
Environmental management techniques for dealing with bulk manure to prevent leaching and emissions?	Yes / No				Yes / No
Renewable energy schemes such as wind turbines, biomass boilers, photovoltaic panels, biodiesel?	Yes / No				Yes / No
Collecting and conserving rainwater?	Yes / No				Yes / No
Grazing management	Yes / No				Yes / No
Energy reduction techniques, such as reducing the use of the tractor, reducing emissions in processing, or different transport beyond the farm gate?	Yes / No				Yes / No

Table A8.8 Q16

Please note the options for iv) 'if not why not' were: Too expensive; What is this, I haven't heard about it; Did use it but it wasn't successful; Not interested; Don't feel it will work on my farm; If other, please describe

Techniques	**i) Using the techniques?**	**ii) For how long?**	**iii) How large an area?**	**iv) If not, why not? *Select one option from list above***	**v) Would you like to know more?**
Zero / Minimum tillage, or other ways to capture greenhouse gases by minimising soil disturbance?	Yes / No				Yes / No
Intentionally sowing deeper rooting plants?	Yes / No				Yes / No
Maintaining permanent soil cover, such as using cover crops (e.g. red clover)?	Yes / No				Yes / No
Converting strips of land at edges of field back to coppices, hedging, grasslands, or wetlands?	Yes / No				Yes / No

Corresponding to 5.4.3, the 2x2 table A8.9 for those who were farming beef and using grazing management.

Table A8.9 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those farming beef and using grazing management techniques

			Grazing management -- Using the techniques?		
			yes	no	Total
Beef - what sector do you farm?	not selected	Count	10	13	23
		Expected Count	14.4	8.6	23.0
	selected	Count	17	3	20
		Expected Count	12.6	7.4	20.0
Total		Count	27	16	43
		Expected Count	27.0	16.0	43.0

Corresponding to 5.4.3, the 2x2 table A8.10 for those who were farming sheep and using grazing management.

Table A8.10 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those farming sheep and using grazing management techniques

			Grazing management -- Using the techniques?		
			yes	no	Total
Sheep - what sector do you farm?	not selected	Count	9	13	22
		Expected Count	13.8	8.2	22.0
	selected	Count	18	3	21
		Expected Count	13.2	7.8	21.0
Total		Count	27	16	43
		Expected Count	27.0	16.0	43.0

Corresponding to 5.4.3, the 2x2 table A8.11 for those who were rent their farm land and who use renewable energy.

Table A8.11 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those who rent their land and use renewable energy such as wind turbines, biomass boilers, photovoltaic panels and biodiesel.

			Renewable energy schemes -- Using the techniques?		
			yes	no	Total
Rent - Do you own or rent your farm,	not selected	Count	14	12	26
		Expected Count	9.7	16.3	26.0
	selected	Count	2	15	17
		Expected Count	6.3	10.7	17.0
Total		Count	16	27	43
		Expected Count	16.0	27.0	43.0

Corresponding to 5.4.3, the 2x2 table A8.12 for those who were applying energy reduction techniques and who use renewable energy.

Table A8.12 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those applying energy reduction techniques and using renewable energy schemes such as wind turbines, biomass boilers, photovoltaic panels and biodiesel.

			Renewable energy schemes -- Using the techniques?	
			yes	no
Energy reduction techniques, such as reducing the use of the tractor, reducing emissions in processing, or different transport beyond the farm gate? -- Using the techniques?	yes	Count	14	15
		Expected Count	10.8	18.2
	no	Count	2	12
		Expected Count	5.2	8.8
Total		Count	16	27
		Expected Count	16.0	27.0

Corresponding to 5.4.3, the 2x2 tables A8.13-15 for those who were applying energy reduction techniques and who use renewable energy.

The 2x2 tables for these are Tables A8.13 (minimum tillage and energy reduction), A8.14 (permanent soil and energy reduction) and A8.15 (converting strips of land and energy reduction).

Table A8.13 Showing the SPSS 2x2 crosstabluation table from the Phase 1 survey data for those applying energy reduction techniques such as reducing use of tractor, or emissions and using zero or minimum tillage

			Zero / Minimum tillage, or other ways to capture greenhouse gases by minimising soil disturbance? -- Using the techniques?		
			yes	no	Total
Energy reduction techniques, -- Using the techniques?	yes	Count	18	11	29
		Expected Count	14.2	14.8	29.0
	no	Count	3	11	14
		Expected Count	6.8	7.2	14.0
Total		Count	21	22	43
		Expected Count	21.0	22.0	43.0

Table A8.14 Showing the SPSS 2x2 crosstabluation table from the Phase 1 survey data for those applying energy reduction techniques and maintaining permanent soil cover

			Maintaining permanent soil cover, such as using cover crops (e.g. red clover)? -- Using the techniques?		
			yes	no	Total
Energy reduction techniques, such as reducing the use of the tractor, reducing emissions in processing, or different transport beyond the farm gate? -- Using the techniques?	yes	Count	17	12	29
		Expected Count	13.5	15.5	29.0
	no	Count	3	11	14
		Expected Count	6.5	7.5	14.0
Total		Count	20	23	43
		Expected Count	20.0	23.0	43.0

Table A8.15 Showing the SPSS 2x2 crosstabluation table from the Phase 1 survey data for those applying energy reduction techniques and converting strips of land

			Converting strips of land at edges of field back to coppices, hedging, grasslands, or wetlands? -- Using the techniques?		
			yes	no	Total
Energy reduction techniques -- Using the techniques?	yes	Count	21	8	29
		Expected Count	17.5	11.5	29.0
	no	Count	5	9	14
		Expected Count	8.5	5.5	14.0
Total		Count	26	17	43
		Expected Count	26.0	17.0	43.0

Corresponding to 5.5.2, the 2x2 tables A8.16 for those who were rearing sheep and constrained by lack of knowledge, and A8.17 for those who did not maintain permanent cover feeling constrained by other constraints.

Table A8.16 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those farming sheep and feeling constrained from farming in a climate friendly way by the lack of knowledge

			Constraints: Knowledge		
			not selected	selected	Total
Sheep - what sector do you farm?	not selected	Count	18	4	22
		Expected Count	14.3	7.7	22.0
	selected	Count	10	11	21
		Expected Count	13.7	7.3	21.0
Total		Count	28	15	43
		Expected Count	28.0	15.0	43.0

Table A8.17 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for maintaining permanent soil cover and feeling constrained from farming in a climate friendly way by other constraints discussed below in section 5.4.3

			Constraints: Other		
			not selected	selected	Total
Maintaining permanent soil cover -- Using the techniques?	yes	Count	11	9	20
		Expected Count	14.4	5.6	20.0
	no	Count	20	3	23
		Expected Count	16.6	6.4	23.0
Total		Count	31	12	43
		Expected Count	31.0	12.0	43.0

Corresponding to 5.6.1, the 2x2 tables A8.18 for those in an environmental scheme who were using zero / minimum tillage techniques, A8.19 for those who were receiving DEFRA subsidies and practicing zero / minimum tillage and A8.20 for those in environmental schemes who were maintaining permanent soil cover.

Table A8-18 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those in an environmental scheme and using zero/minimum tillage

			Zero / Minimum tillage--Using the techniques?		
			yes	no	Total
Are you in an environmental rated scheme?	yes	Count	20	12	32
		Expected Count	15.6	16.4	32.0
	no	Count	1	10	11
		Expected Count	5.4	5.6	11.0
Total		Count	21	22	43
		Expected Count	21.0	22.0	43.0

Table A8.19 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those in an DEFRA schemes such as ELS, or OELS and using zero/minimum tillage

			Zero / Minimum tillage--Using the techniques?		
			yes	no	Total
Defra's environmental stewardship schemes	not selected	Count	4	12	16
		Expected Count	7.8	8.2	16.0
	selected	Count	17	10	27
		Expected Count	13.2	13.8	27.0
Total		Count	21	22	43
		Expected Count	21.0	22.0	43.0

Table A8.20 Showing the SPSS 2x2 crosstabulation table from the Phase 1 survey data for those in an environmental scheme and maintaining a permanent soil cover.

			Maintaining permanent soil cover, such as using cover crops (e.g. red clover)? -- Using the techniques?		
			yes	no	Total
Are you in an environmental rated scheme?	yes	Count	18	14	32
		Expected Count	14.9	17.1	32.0
	no	Count	2	9	11
		Expected Count	5.1	5.9	11.0
Total		Count	20	23	43
		Expected Count	20.0	23.0	43.0

Appendix 9 - Showing summary of the group interview comments using the Ketso kit for Embedding RegenAG in the UK

Table A8 showing the group interview for embedding RegenAG in the UK.

Branch	Leaf Colour	Leaf Type	Participants' idea
Communication and Network	Brown	Strengths	Fantastic knowledge being shared
Communication and Network	Brown	Strengths	Regular email bulletins and communication
Communication and Network	Green	Weaknesses	Sometimes need someone with experience to help
Communication and Network	Grey	Opportunities	Collaboration and exchange
Communication and Network	Grey	Opportunities	Public awareness growing
Communication and Network	Grey	Opportunities	Each of us bringing 3 new people in
Communication and Network	Grey	Opportunities	community - led enterprises
Education and Research	Brown	Strengths	Great courses
Education and Research	Brown	Strengths	Courses
Education and Research	Brown	Strengths	Meeting like minded people

Education and Research	Brown	Strengths	Diversity of practitioners and course attendees
Education and Research	Green	Weaknesses	Lack of public understanding
Education and Research	Green	Weaknesses	Evidence (lack of)
Education and Research	Green	Weaknesses	Lack of long-term studies / precedents
Education and Research	Green	Weaknesses	UK research
Education and Research	Green	Weaknesses	Agricultural mainstream education conservative
Education and Research	Green	Weaknesses	Lack of knowledge / skills base
Education and Research	Grey	Opportunities	RegenAG intern scheme alongside permaculture intern scheme
Education and Research	Grey	Opportunities	Agricultural education into colleges for new approaches
Education and Research	Grey	Opportunities	Universities with research opportunities
Education and Research	Grey	Opportunities	Sharing knowledge
Education and Research	Grey	Opportunities	RegenAG - blitzes? like permablitzes
Education and Research	Yellow	Threats	Mis-information
Education and Research	Yellow	Threats	Conservatively in farming
Practical and Demonstration	Brown	Strengths	Some farms are already doing
Practical and Demonstration	Yellow	Threats	Distance between practitioners
Practical and Demonstration	Grey	Opportunities	Demonstration network of UK projects
Practical and Demonstration	Grey	Opportunities	Support of experienced practitioners
Practical and Demonstration	Grey	Opportunities	Visibility @ other agricultural shows and conferences
Practical and Demonstration	Grey	Opportunities	UK farming diverse so opportunity forming
Practical and Demonstration	Grey	Opportunities	Upland farm 40 acres near Rossendale Lancashire opportunity

Health	Brown	Strengths	Paleo / Coeliac
Health	Brown	Strengths	Nutrient dense food
Health	Green	Weaknesses	Wellbeing / mental / stress / isolation
Health	Green	Weaknesses	Lack of public awareness of RegenAG UK and health
Health	Grey	Opportunities	Antibiotic overuse becoming a big issues
Health	Grey	Opportunities	Health - evidence increasingly shows industrially produced food can be harmful
Health	Grey	Opportunities	Diverse sward nutrition pollinators
Health	Grey	Opportunities	Health services overloaded, no money and need new approaches
Health	Yellow	Threats	Nutrition
Health	Yellow	Threats	"Bad for Health" in media
Environment	Brown	Strengths	Wildlife gain
Environment	Brown	Strengths	Ability to build soil
Environment	Brown	Strengths	Increased biodiversity
Environment	Brown	Strengths	Minimum inputs
Environment	Grey	Opportunities	Flood resilience
Environment	Grey	Opportunities	Ideas / engineers to help
Environment	Grey	Opportunities	Potential Agro environmental schemes
Environment	Grey	Opportunities	Carbon Sequestration
Environment	Grey	Opportunities	Bio char utilisation in carbon sequestration
Economics	Brown	Strengths	Reducing Carbon

Economics	Brown	Strengths	Finite resources should drive low input processes
Economics	Green	Weaknesses	Big companies hold status quo
Economics	Green	Weaknesses	Financial Visibility?
Economics	Green	Weaknesses	High Capital outlay
Economics	Green	Weaknesses	Embedded 1947 approach to agriculture in UK
Economics	Grey	Opportunities	Moving beyond fossil fuels
Economics	Grey	Opportunities	Sharing viable business plans and non-competitive open books
Economics	Grey	Opportunities	The old system is bust and so are perverse subsidies
Economics	Grey	Opportunities	Conventional Ag has no answers
Economics	Yellow	Threats	Big business holds the status quo
Economics	Yellow	Threats	Biotechnology and intensification solutions threats
Economics	Yellow	Threats	Agribusiness
Economics	Yellow	Threats	Critics on animal farming
Economics	Yellow	Threats	The military - industrial complex
Governance / Leadership	Brown	Strengths	Inspiration
Governance / Leadership	Brown	Strengths	Integrated Vision
Governance / Leadership	Brown	Strengths	Strength in numbers
Governance / Leadership	Brown	Strengths	New models of agriculture needed and RegenAG can help
Governance / Leadership	Grey	Opportunities	Alliances with other like minded organisations e.g. wildlife trusts
Governance / Leadership	Grey	Opportunities	Reform of CAP to support ecological services
Governance / Leadership	Grey	Opportunities	UK "Island" opportunity for leading field

Governance / Leadership	Grey	Opportunities	Currently no GMOS!
Governance / Leadership	Yellow	Threats	Negative oil-pro government
Governance / Leadership	Yellow	Threats	Restrictive legislation / regulations

Appendix 10 - Looking over the electronic hedge: Learning new farming technique

This was written for Coventry University Research Blog[98] during the writing up year for this thesis and is replicated below.

Farmers have traditionally shared knowledge and new techniques with their farmer neighbours via local farmer meetings, pub visits and chatting over the hedge between each other's fields.

Whilst I have been investigating agroecological farming methods in the UK in relation to climate change, it has become apparent that geographical distance separated those farmers who were using, and could be sharing about, the same techniques. For example, one farmer I interviewed who was farming using agroecological techniques learnt at a Regenerative Agriculture course (RegenAG UK 2013) was in the north of the country, but was surrounded by conventional farmers, whilst the closest agroecological farmer using those methods was on his own in the Midlands.

To overcome this, knowledge sharing has spontaneously evolved by farmers at opposite ends of the country, so that they are now able to chat about their successes and difficulties in implementing new farming techniques such as mob grazing through the Internet, forums, emails, YouTube and social media. It became apparent to me that they had transformed the traditional hedge to an *electronic hedge*, over which they shared knowledge online.

"So what we learn online from other people or visiting other people, we can apply to our context and take bits from here and there."

(Farmer RH, Midlands, 2016)

One successful example of this is the Pasture-Fed Livestock Association (PFLA) google group (PFLA 2015). The farmers in this group all keep their cattle or sheep out on grass or pasture land for most of the year, only bringing them in when the fields get too wet or cold. Many have begun to apply mob grazing techniques which involve splitting up

[98] http://blogs.coventry.ac.uk/researchblog/looking-over-the-electronic-hedge-learning-new-farming-techniques/

your field into small paddocks and then moving your animals from paddock to paddock every day, only allowing them one day to graze a section. This improves the soil and grass quality, which in turn improves the health of the animals[99]. Any farmer in the PFLA who needs advice about mob grazing or other techniques can ask their questions on the google group and many will reply with useful answers. As the google group is for members only, it enables them to ask questions which might seem simple, without feeling stupid.

> *"I think I posted the question about running out of grass and not having much silage and then there was a huge slate of replies from lots of other people. There's been a couple of questions I posted on it, they have resulted in an awful lot of discussion. I have found it a really useful tool, the pasture fed Google group." (Farmer PV, South-East, 2015)*

Using the electronic hedge, has not only enabled farmers to share and learn with other interested farmers, who were geographically disparate, but also has helped those farmers in more isolated areas to feel connected to a networked and connected community of farmers who all employ agroecolgical techniques. The use of YouTube, Skype, web cameras and emails enables electronic peer to peer learning. It also allows mentoring of a farmer using a new technique by one who is further along in applying that agroecological method.

> *"We are really in a very traditional farming area, so to have somebody who could, I don't know just lean over the gate, or be at*

[99] Whilst mob grazing is a new technique, it is based on rotational grazing which has been around for centuries, in fact there is a saying amongst farming that I have heard repeated frequently when attending Farm Walks and on farm workshops which says "Sheep should never hear the church bell twice in the same field" (i.e. assuming the church bell only rings on a Sunday, and you don't (like I do) live near a church that has weddings and bell ringing practice frequently, you would move your sheep at least once a week). So to some extent mob grazing is just more intense that the original rotational grazing.

the end of the phone and say 'you are doing this, but how about doing that?' That would be really useful, it's a sort of mentoring role really." (Farmer A, North-East, 2015)

The sharing of farmer knowledge over a hedge is no longer physically between two fields, but instead, via the Internet, the virtual hedge spans the country, allowing one farmer in Northumberland to talk to another farmer in Cornwall and view their techniques. It enables farmers to move beyond the conventional farming in their area, and be supported in creating change which is invaluable in improving the quality of soil, animal health, and their own livelihoods.

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Appendix 11 - The role of Internet and social media in the diffusion of knowledge and innovation among farmers

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Keywords: social media; farmer innovation; agroecology; internet.

[100] This conference paper was written for the 2016 IFSA Conference and is available at http://www.harper-adams.ac.uk/events/ifsa-conference/papers/1/1.5 Burbi.pdf

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Appendix 12– Brexit – any help, vulnerabilities or limitations.

As over the course of analysing the data and writing up this thesis the topic of Brexit and its impact on the UK and its agriculture sector became prominent, this section (written in December 2016) uses data provided by the interviewees, news articles, government debates, and institutional reports to assess possible hazards to agroecology and UK farmers' livelihoods. It is now to some extent out of date as government talks have continued. However, until the talks are concluded, some predications of impacts on UK agriculture are likely to be speculation, this section remains in situ.

Brexit, the economy and the cost of food

Since the result of the referendum in June 2016, there have been worries about the economy and in the latter quarter of 2016, the price of food. For example, worries over the rising cost of Marmite hit the news in October 2016 (Toynbee 2016, Butler 2016a) when Unilever increased prices due to the drop in the pound. By the end of October, the price of Marmite had increased by 12.5% in Morrisons stores (Butler and Kollewe 2016). The MP Nick Clegg published a paper stating that as 70% of all food imported comes from the EU, and more than two thirds of our exports go to the EU (Clegg 2016), food costs will increase as the value of the pound decreases. They could get even worse once the UK leaves the EU if tariffs have to be paid on exports. Clegg's paper discusses how one shortbread maker found the cost of butter had increased by 75% (Clegg 2016). What Clegg's paper did not discuss though, was whether the butter was sourced from the UK, which would have indicated that the price of domestically produced products are also increasing. The ingredients for Marmite are sourced, and the product made in the UK (Parveen 2016). As the cost of the pound not only impacts on goods and services bought, but also the sale of products, this could suggest a long-term trend of shock and stresses to UK farmers. However, the senior vice president of Tate & Lyle sugar argues that it is not as bad as Nick Clegg says, given that sourcing sugar outside of the EU is already subject to seriously high tariffs, adding 40 million pounds to the company's raw material bill last year (Mason 2016). The Agricultural and Horticultural Development Board (AHDB) point out that in 2015-16, 80% of wheat, nearly all rapeseed and two thirds of barley were being exported to the EU (Howarth and Baker 2016). After leaving the EU, the UK may have to charge higher costs for exporting those goods due to tariffs, customs costs and conforming 'with minimum EU standards' (Clegg 2016). This could mean that other European countries like the Ukraine take over wheat exports to the EU (Verdin 2016) and the UK will have to export elsewhere, potentially leading to the agricultural sector finding traditional crops are no longer financially viable (Lydgate 2016).

Brexit and migrant farm workers

Another issue from the Brexit decision that would increase the cost of food production for farmers would be labour. At least 20% of agriculture employees are EU nationals, and as this figure does not consider seasonal workers; it could be even higher (Swales and Baker 2016). Some farmers feel that if immigration controls were to prevent seasonal workers from entering the UK (based on non-EU immigration rules (Barber et al. 2016)), 'within five days' there could be no fresh British vegetables in supermarkets (Sims 2016, O'Carroll 2016). 38% of all migrant workers in the UK work in food production, with the highest labour-intensive sectors being 'horticulture and specialist fruit' (Swales and Baker 2016: 9). It is unlikely that those positions would be filled by UK workers as 'farmworkers make up less than 1% of British workforce…. With only 4% of young people considering a job in food and farming' (Nye 2016).

Furthermore, 'agriculture has one of the highest proportions of hard to fill vacancies' (Swales and Baker 2016: 7) due to a variety of reasons including unsociable hours, seasonal vacancies only, remote locations and not enough people interested (Fredenburgh 2016). However, as agricultural wages in the UK are traditionally higher than the EU average, and only lower than five other EU countries, agricultural jobs are more attractive to workers in EU countries with high unemployment and low wages (Swales and Baker 2016). To make matters worse, recent news reports have indicated that ‘anti-migrant’ sentiment, along with the drop in the value of the pound (thus reducing the value of UK wages in other EU countries), has significantly reduced the number of EU nationals who have applied to work in the UK food industry during the 2016 Christmas peak. *The Guardian* reported that the shortage of workers was the severest since 2004 (Butler 2016b).

The NFU hopes to encourage the government to allow seasonal workers to continue in 2017 and is discussing longer-term solutions such as continuing to allow migrant work for food production, along with promoting the agricultural sector as a positive career in schools and colleges across the UK (NFU Policy Directorate 2016). Given the current value of the pound, and that the latter option will take time to implement and embed as a suitable job option for young adults, the lack of workers could prove to be a long term trend of stress, if not a hazard, for farmers.

Another alternative to employing migrant workers is to increase research and production into automation. As mentioned in Chapter 6.5.3, automated technology can allow tractors to drive across a field without a farmer and one interviewee suggested that technology would develop so far that people would see: “Automated cars, and tractors in a field, because there is no one to run into!” (Farmer GB, Midlands, 2015).

The NFU hope that AHDB and the government will invest in robotics and automation (NFU Policy Directorate 2016) and AHDB themselves also consider it a good alternative to the cheap migrant labour workforce (Swales and Baker 2016). Even the Campaign To Protect Rural England (CPRE) feel that government initiatives for robotic weeders will enable small-scale horticulture to reduce costs and work capacity whilst the weeder’s 'small size and low weight all but eliminates soil compaction problems' (CPRE and Willis 2016: 23).

However, both AHDB and CPRE admit there are problems to automation including the cost of investment, along with the fact that the scale of most robotics are better suited to large farms (CPRE and Willis 2016), and the fact that some sectors require a large workforce, which may not suit automation (Swales and Baker 2016). Furthermore, the lack of surety of investment along with immigration policies may create a 'climate of uncertainty' (Swales and Baker 2016: 15) where farmers may not wish to invest in automation if next year the government allows migrant workers (costing less than replacing with robotics). Finally, AHDB points out that the time it would take to design, plan, build and rollout the automated robots would leave farmers without workers for a considerable length of time (Swales and Baker 2016).

Brexit, subsidies and farmer funding

Subsidies and the CAP are another area of concern amongst farmers given many farmers may find their income declines without subsidies (Van Berkum et al. 2016). One farmer interviewed benefited greatly from government funding and commented on the fact that previously they made a loss financially on their farm, but since they were accepted onto the high level stewardship scheme, they were making a profit (Farmer AC, South-West, 2015).

The government has promised to continue 'current levels of funding until 2020' (UK Government 2016). However, many farmers are concerned about whether or not their subsidies will continue beyond 2020, and are either making decisions not to proceed with improvements to their farms, or are pausing those improvements until it becomes clearer (The Earl of Kinnoull, House of Lords Hansard 2016).

There has also been great discussion over who has received CAP funding, when the reformed 'greening of the Common Agricultural Policy resulted in farmers mostly being paid depending on how much land they own' (Harrabin 2016). This led to the Queen, Duke of Westminster, Duke of Northumberland and a billionaire Saudi Prince (amongst others) receiving large sums of the subsidies (Harrabin 2016). Instead, campaigners, journalists, members of the House of Lords and CPRE along with the NFU all feel that the subsidies should be revised and benefit environmentally friendly farming (CPRE and Willis 2016, House of Lords Hansard 2016, Lydgate 2016).

However, for the average farmer benefiting from the CAP funding scheme, one interviewee felt it might encourage better farming practices:

> "The new requirement under the basic payment scheme is what they call Greening, which is an EU initiative, but basically you can't just have nothing but wheat, you must (I think, because I don't really need to do it, so I don't know that much about it) have three different crops (it does depend on the area) and you can't have any one crop for a certain percentage of the time. So that will encourage the growing of other crops…" (Farmer GB, Midlands, 2015).

Brexit and biodiversity

As noted above, some of the subsidies have benefited the land, soil and biodiversity: 'For three years land has been dedicated to buffer strips grass field corners and pollen and nectar mixes as a part of the ELS scheme' (Farmer response in survey, winter 2013-14).

This is positive considering *the Mid-term review of the EU biodiversity strategy to 2020* to 'halt the loss of biodiversity and the degradation of ecosystem services in the EU… and restore them in so far as feasible' felt that no progress had been made to achieve that target (European Environment Agency and European Commission 2016: 1). To add to the issue, the *State of Nature 2016* report produced by over fifty organisations states in their headlines from the report that: 'A new measure that assesses how intact a country's biodiversity is, suggests that the UK has lost significantly more nature over the long term than the global average. The index suggests that we are among the most nature-depleted countries in the world' (Hayhow et al. 2016: 6). However, the report also contains some positive data such as 'the return from UK extinction of the large blue butterfly and pool frog' (Hayhow et al. 2016: 15) along with the increase of bats (including the lesser horseshoe bat) by 23% since the Millennium (Hayhow et al. 2016).

One farmer, in their completion of the survey, even noted that whilst they had seen a reduction in most species on their farm, they had seen an increase in red kites (as discussed in Chapter 5.2.3). In one interview, the farmer explained enthusiastically how rare and species rich her farm was:

> "Because we've got 350 species of plant here…. We've already had quite a few farmers come over to collect seed from flowers….. Have you ever seen a wax capped fungus?... They come in crimsons and scarlets…. And yellows and whites and blues and purples and greens… They're just incredible. We've got over 14 species of the wax caps plus other extraordinary things like meadow coral. So if you can imagine a yellow coral growing under the sea, you can just get it coming in a clump between your grass and white spindles which come up in six white threads like knitting needles coming out of the ground in clumps... It's just so exciting" (Farmer AC, South-West, 2015).

Once the UK leaves the EU, the Government needs to ensure that the UK's biodiversity does not come to harm with a reintroduction of pesticides and genetically modified organisms (GMO) that scientists for the EU believe impact negatively on farm wildlife.

In a report published in August 2016, members of the farming community such as the NFU, and the UK Government, felt that the scientific evidence provided did not support the EU restrictions and instead was reducing the UK farmers crop production[101]. The report states that 'The UK resistance to these decisions indicates

[101] 'The EU approval and assessment process has recently received a great deal of attention because of the European Commission's introduction of restrictions on a number of the most commonly used neonicotinoid insecticides, due to their negative impact on bees. The UK Government does not agree that the scientific evidence supports the restrictions but the Commission had sufficient support to introduce them…. In addition, the renewal of the approval for the herbicide glyphosate has been

that there would be a very different approach to pesticides approval with more UK autonomy' (Barber et al. 2016: 64) and that farmers cannot cope without the pesticides. However, a journal article published on the 16th August 2016 provided data from real field situations of bees foraging on oilseed rape between 1994-2011 and provided evidence that wild bees (not honeybees or bumblebees) were declining due to neonicotinoids (Woodcock et al. 2016). Another article published later in 2016 (without any reference to the Woodcock et al. article and with the admitted conflict of interest in that the authors had links to Bayer CropScience AG) found that there was no evidence that the neonicotinoid clothianidin caused any detriments to honeybees, bumble bees and mason bees (Schmuck and Lewis 2016). The debate has died down over the winter 2016, but as the UK moves away from Brexit, neonicotinoids may or may not be approved for use by UK farmers. Conversely, one interviewee pointed out:

> "Look at neonicotinoids, the rape crop this year was better without it. It was all 'oh we must have neonicotinoids or we'll have no crop' and then we have a recording breaking crop without it and they've still got the derogation to use it again which is absolutely crazy!" (Farmer GB, Midlands, 2015).

Exploring further how the UK's biodiversity might be influenced once farmers lose the CAP subsidies, the NFU feel that a 'voluntary measure… aimed at protection of landscape features, biodiversity, climate mitigation, soil and water care' (NFU Policy Directorate 2016: 10) will be enough. Nevertheless, as mentioned above, campaigners and wildlife organisations (Friends of the Earth 2016) want stronger legalisation 'which delivers high environmental standards for land management and supports farmers and others to do this' along with payments to farmers which 'safeguard the natural environment' (Brodie et al. 2016: 2).

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delayed at EU level after conflicting scientific assessments. It now has approval for 18 months pending a further study by the EU Chemicals Agency. The UK is arguing that the scientific assessments carried out so far do not suggest that certain uses of glyphosate should be restricted at EU level, and that it should be for Member States to consider whether restrictions are needed as part of their national re-approval processes' (Barber et al. 2016: 64).

Over the next few of years, Brexit may prove to be a hazard for farmers' livelihoods, the environment and in responding to climate change, or a force for good.

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